APR 11 1932

Engineering News-Record

Three Articles of Commanding Interest:

Model Tests of Hoover Dam

By J. L. Savage and Ivan E. Houk

Proposed Realignment of the Cement Industry

By Q. Fred Rost

Streamflow From Unit Graphs of Runoff

By L. K. Sherman

Also

Gulf Oil Building in Pittsburgh

Ridge Road Bridge in Rochester

New York Engineer License Law

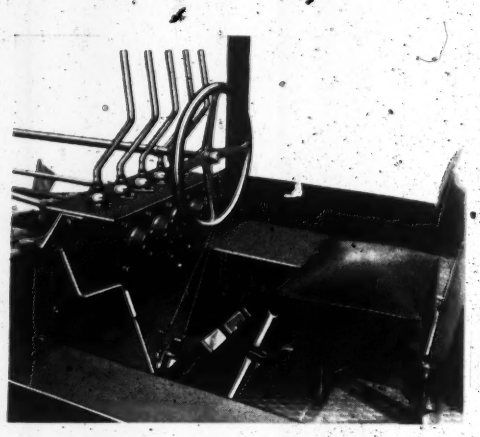
Twenty-five cents; Five dollars per year

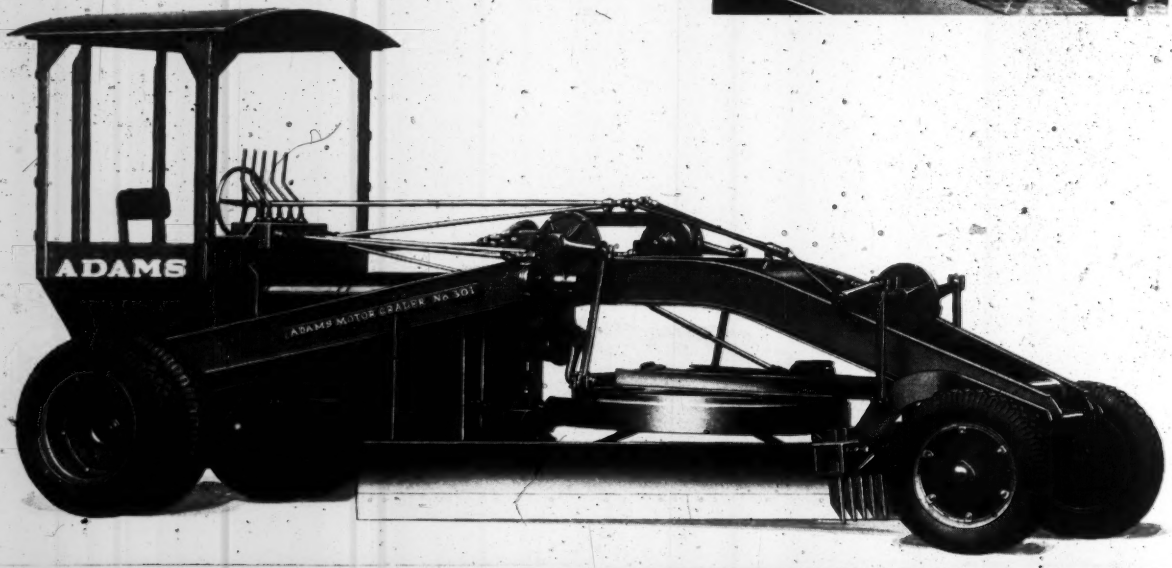
April 7, 1932

McGraw-Hill Publishing Company, Inc.

Announcing a New **ADAMS MOTOR GRADER**

• MOTOR CONTROLLED •





Powered by New McCormick-Deering I-30 Tractor

INSTANT control, quicker adjustments, more efficient operation—these are the advantages to be derived from the fully motorized controls on the new Adams Motor Grader No. 301. From his comfortable cushioned seat, the operator has a clear view of both ends of his blade and makes all adjustments quickly and practically without effort by means of the convenient control levers in front of him. Energy is saved—efficiency is increased—more and better work is done.

The McCormick-Deering Tractor used is a new and improved product of the International Harvester Company; it is economical, dependable and has an abundance of power.

Like all Adams Motor Graders, this machine is of all-welded, machine-finished construction, resulting in remarkable strength and rigidity, smooth cutting qualities, long life and surprisingly low up-keep cost. It is furnished with 10, 12, 14, or 16 ft. blade, with or without scarifier and with dual rear wheels as illustrated or Adams Tandem "Four-Wheel" Drive.

Write for special new folder describing this new machine—also catalogs on Adams Leaning Wheel Graders, Elevating Graders, Road Maintainers, Retread Machines, etc.

ADAMS ROAD MACHINERY

J. D. ADAMS COMPANY, Indianapolis, Indiana

Minneapolis Kansas City Dallas Atlanta Memphis Spokane

Engineering News-Record

Established 1874 ✦ A Weekly Journal of Civil Engineering and Construction Practice ✦ McGraw-Hill Publishing Company, Inc.

F. E. Schmitt, Editor

Volume 108 | New York, April 7, 1932 | Number 14

Two May Prevail

IF PROFESSIONAL men join hands in working out the great problem of building up a construction industry and leading its component elements to meeting their difficulties by cooperation, the undertaking has bright hopes. The Construction League meeting at St. Louis gave such promise, for architects and civil engineers worked together harmoniously in giving impetus and direction to the movement. Either professional group alone would probably fail in the task, for it is of formidable difficulty, but together they can succeed. Architects and engineers have been strangers for years. Old, intangible misunderstandings and elements of strangeness have kept them apart in work that concerns them both. It is one of the few items of profit of times like these that their traditional strangeness is recognized as wrong. The two professions deal with the full range of construction activities; they are the starting point of all building, the motive and inspiration of what the constructor achieves, from foundation to coping stone. Together they can lead construction to new powers.

Leading Articles

Model Tests of Hoover Dam 491
Licensing Engineers in New York 497
Unit-Graphs to Measure Streamflow 501
Floors of Gypsum and Concrete 506
Ridge Road Bridge in Rochester 507
Gulf Oil Building in Pittsburgh 510
Reorganization in Cement Industry 513

Waterworks vs. Opera

UNCONSCIOUS irony is contained in two editorials in the current issue of *Commerce*, the monthly magazine published by the Chicago Association of Commerce. The first of the two discourses in popular vein on governmental costs, and reaches its climax in quoting the president of the Chicago & Northwestern R.R.: "Unless the business men of Chicago are united and coordinated in a militant drive with the single objective of reducing governmental expenditures and balancing budgets, the prosperity of the city will be threatened for years to come." Directly following this ringing challenge comes a discussion of the financial difficulties of the Chicago Symphony Orchestra and the Chicago Civic Opera Co. Unless the orchestra can raise $82,000 to reduce the deficit from last season's operation, no concerts will be heard next winter, and unless a guarantee fund of $500,000 is made available to the opera company, no operatic activities will be enjoyed. In bestowing its blessing upon the efforts being made to raise the required sum, *Commerce* continues: "Grand opera, in its capital class, has become as institutional as the waterworks. The splendid concerts of the Chicago North Shore Musical Festival Association will go on, and as for Ravinia—we must have it." A topsy-turvy world indeed! Chicago's waterworks employees have their pay cut 20 per cent, and work on a partly finished intake tunnel is discontinued because public support has failed. But as for outdoor opera, "we must have it." The "frills" must be cut out of our educational system, but symphony concerts must go on!

Calculating Streamflow

A NEW method of determining the runoff of a given stream from the known records of rainfall is proposed by L. K. Sherman in this issue. Using a single observed hydrograph due to a storm of 24-hour duration, Mr. Sherman has developed a method of computing what the runoff for the same watershed will be for a storm of any duration or degree of intensity. With less accuracy the method may be applied to estimating the runoff from a watershed having like characteristics. The method is valuable as a new approach to the old problem, so often encountered in flood-control, drainage, water-supply or water-power studies, of determining from rainfall records what runoff may be expected in the absence of adequate runoff records. Constructing a "unit-graph" from the record of one storm of known length and intensity, the author determines a runoff record which automatically includes the effect of such unknowns as surface and channel pondage. Obviously the method is not perfect—no method of advance determination of results involving so many variables as streamflow can be perfect—but its application to watersheds of known runoff characteristics gives results so close to the observed runoff as to mark the method as a valuable contribution to the study of hydrology. It warrants full study by engineers to determine its limitations as well as its possibilities.

Designing Dollars Into Buildings

THE structural steel layout and make-up in some of our modern buildings suggest that building frames are not always the standardized product that they are generally thought to be. Often ingenuity and design ability of high order are required to meet special conditions, such as existed, for instance, in the Kansas City Power & Light building, completed last year. A more recent example, the Gulf Oil building, in Pittsburgh, represents a unique design, not because of special conditions but because of a desire to improve the efficiency of the building. Two features of the design that deserve comment are the long-span floor framing and the three-web columns. Both increased the usable space and therefore enhanced the value of the building. By means of double girders, spans up to 35 ft. were used in one direction.

eliminating all columns from the rentable portions of a 30-story tower. Allowing 4 sq.ft. to each column, this represents an appreciable addition of space and increased dollars in rent per floor. The three-web columns, while they did not save space in this particular building (since they were placed in walls), are also potential space-savers. They are not unique in make-up, but might be taken as a retrogression from existing practice, since instead of utilizing a heavy rolled H-section as a core they are built up wholly of plates and angles. For heavy sections requiring three or four webs, such "old-fashioned" columns can be shown to save space by concentrating a greater section of steel in a smaller area. Comparative sections have been drawn up, using built-up and H-core construction, providing 672 sq.in. each, in which each built-up column with its fireproofing saves 2 sq.ft. in floor area over the H-core column. These examples should indicate to building owners that the engineer's true asset is design and not mere drafting. The latter may provide the architect with a frame upon which he can hang his building, but it is design that gives the owner the most for his money.

Join the Fight!

COMPARISON of the indicators of conditions in the general construction field with those of previous years indicates clearly that that branch of industry is likely to contribute little or nothing toward relieving unemployment this year. The *Engineering News-Record* curves of new capital and of contract awards are much below last year's and very far below those for 1930. Municipal and state financing for the first quarter reported by *The Bond Buyer* is only $256 millions, the lowest figure since 1923. Considering the many industries whose prosperity is directly dependent upon new construction work, as well as the many others that are indirectly concerned, it is obvious that the curtailment of public works by states, counties and municipalities which has been under way in the past few months is playing no small part in checking an upturn in general business conditions. The effect of all this upon civil engineers and upon general contractors is becoming more apparent every week. A few engineers who have kept in close touch with the unemployment situation among engineers have realized for some time that unemployment conditions will become critical this year unless something can be done to check the receding tide of public construction. This realization resulted in a number of them appearing before a Senate committee recently to urge the adoption by the federal government of some plan for financing all classes of public work, especially that of the smaller governmental units. More recently recognition of the approach of this critical condition resulted in the adoption at a meeting of the American Society of Civil Engineers of a resolution indorsing the action of the engineers who appeared before the Senate committee and urging upon the society's local sections the need for active support of movements designed to stimulate public works. The movement is worthy of full and active support. Unless the curtailment of public construction is soon checked, the season will be too far advanced to permit any considerable amount of new work to get under way before next winter. Construction means not only activity for engineers, architects and contractors, as well as the long chain of industries which supply the materials and machines, but also employment and business. Lack of construction means unemployment and no business.

Safe Dams and Model Tests

ANXIETY over the safety of dams has agitated m as long as dams have existed, and in some measu always will be of concern. We are fortunate in livi in a generation that is attacking the problem with t most powerful tools of scientific inquiry and is pr gressively building up reassurance. The intense activ in study of dams during the past half dozen years, a particularly since the St. Francis dam was swept ou is in itself a guarantee of progress; its results carry ou the promise.

A place of high importance must be accorded the resul of the investigations that are being made to verify th work of the Hoover Dam designers. Already—though they are not yet completed—their major results as re ported by Savage and Houk dispose of many disturbing apprehensions. While doing so they establish new land marks in the history of the art.

First, they establish that the dam now being erected in Black Canyon of the Colorado River, a barrier far higher than its boldest predecessor, will be a thoroughly safe structure. The present tests do not vouch for foundation and abutments, but assurance as to these has been given by geologists, and the explorations of the contractor's tunneling forces are supplying further practical certainty that the rock is sound. Together, these facts answer for the safety of the project.

Second, the results support the modern trial load method of analysis of dams by a solid substratum of measured fact. Heretofore this method rested only on the broad laws of action of materials under stress; but because of the unique character of the problem it required verification by physical measurement. That has now been accomplished, through the work on the 60-ft. Stevenson Creek dam and the close check between dam, model dam and calculation; and through the equally effective check between the models of the Gibson and Hoover dams and their calculations. Thus we are now able to say that a dam analyzed and designed by the trial load method, and so built as to carry out the essential data of the analysis, will stand in true accord with the showings of that analysis.

In these facts lies also the third valuable result of the present tests—namely, their demonstration of the value of tests on models, when carefully made. The civil engineering arts are in a new era of model testing, after a lapse of many decades. Though model testing has sometimes been carried to the point of faddism, yet in its proper application it is the best resource at our command for predicting the behavior of an engineering structure. Reasoning from the behavior of one structure or machine to the behavior of its replica is a process that underlies all engineering work, and one whose value no one can deny. The model is essentially a replica altered in scale to suit it to close investigation under controlled conditions, and therefore partakes of many of the advantages of replica verification. But it has suffered from the enthusiasm of its friends no less than from the unavoidable limitations that inhere in change of scale. Therefore the present demonstration of the value of well-planned model tests is timely.

While taking note of these accomplishments of the Hoover Dam investigations we may properly recall that many great undertakings in the civil engineering field have had epoch-making byproducts of improved knowledge. It is the privilege of the men who direct such undertakings to carry truth forward beyond the known

domain; the studies connected with the Camden and Fort Lee bridges and those at the Vicksburg River laboratory are practical exemplifications. The Stevenson Creek and Hoover Dam studies, ranking with the most notable prior instances, reflect distinction on the group of men who inspired and executed them.

Industry's Opportunity

MUCH talk has been heard about economic and industrial stabilization since 1929, but unfortunately nothing has yet been accomplished. A magnificent opportunity lies before the industries to plan definitely for stabilization of their fields. For just as each individual business concern is engaged in earnest self-analysis to refine its efficiency and economy, so each industry as a unit has the same obligation. And the present is an exceptionally favorable time for such reconstruction efforts. The problem is no easy one, and organizational ability of highest order is demanded. O. F. Rost's study of realignment in the cement industry brings this out and constitutes a tangible contribution toward the solution of the problem.

An example of the results that can be accomplished by action based on a well-directed plan is offered by the improvement that has come to pass in the oil industry through state regulation of production. The plan there applied, a plan specifically adapted to industries dealing with natural resources, evidently is not suited to the manufacturing industries. For them, proper organization to serve the demand is the logical course. This is the course followed in the proposals outlined by Mr. Rost.

Under the circumstances of the present times, when the world is indiscriminately dumping the products of human enterprise and skill, the foremost question is how the large capacity that was provided for former days can be adjusted to greatly diminished wants. In due time, no doubt, demand will again be heavy and much of our idle productive capacity will be restored to service. But demand will always be subject to rise and fall, and therefore flexible adaptation of output to demand will remain a foundation stone of industrial stability. Efficiency in production and distribution cannot exist without it.

Cement is typical of many industries. Because of its dominating position in construction it is of special importance, but after all its problem is representative. All industries are in much the same position; they lack flexibility and therefore are not efficient. All have similar internal problems—excess capacity, physical and human obsolescence, unbalanced distribution, variable commercial policies, and the like. But in addition each industry has its individual complications.

An example of these in the field of cement is the system of dealer distribution; cement has not made the same success here as has the automobile industry. Large and small buyers constitute a further difficulty, for the same commercial policies are not adapted to both. Contractors long ago rebelled at being taxed to pay tribute to a dealer who rendered them no service, and they disliked the workings of a control system that was intended to limit purchases to specific jobs. Bulk buying by state highway departments became another disturbing element.

Quality standardization also affects the cement situation profoundly, for in spite of its value it has proved restrictive in many ways. A standard for material is almost sure to be too high for some uses and too low for others, and necessarily ignores differences in character of service. Standardization built up a belief that any cement is the equal of any other, and that instead of defining a minimum of quality the standard defines high quality. Such beliefs thrive specially well because our available test methods are inadequate and do not succeed in giving a true measure of performance. Thus standardization discouraged progress in the art, and the industry largely resigned itself to producing a bulk staple and to competing in service and price alone.

Though such individual complications affect all industries, yet the controlling factors that constitute the real problem of reorganization are essentially the same in each: excess capacity, obsolescence, and an industrial structure incapable of correlating production with demand for best service.

That stabilization of industry is essential to the country's economic welfare has come to be fairly well understood; but, as said at the outset, no definite progress toward such stabilization has yet been made. Mere drifting will not bring a solution. Mere adjustment of present price conflicts will bring no real progress, either in assuring the worker continuity of employment or in protecting the public from the large losses which the present system entails. If, on the other hand, industries would study and plan out their own reconstruction to the end of providing a more efficient and flexible industrial organization, great rewards would accrue not only to industry but to the entire community.

Turning the Tide

AN ORGANIZATION of the industries interested in roadbuilding in New York is carrying the question of wholesale diversion of motor-vehicle taxes direct to the voters. As stated in more detail in the news pages of this issue, just short of 47 million dollars of a 93 million dollar income from gasoline and license taxes are diverted from highway improvement to the general tax fund. Specifically, the legislature has increased the impost on road users about one-fourth and has reduced the expenditure for roads about two-thirds. This is the greatest raid ever made on the money paid by motor-vehicle operators for highway service.

In carrying the protest against such piracy direct to the taxpayers the roadbuilding industry has for the first time gone beyond voting resolutions. It is a credit to New York roadbuilders that they have seen their way to direct action. Such action has been repeatedly urged in these columns as the only effective way of combating the agencies which seek diversion of the taxes paid for highway service. These agencies act directly and not by pronouncing generalities. They acted successfully in New York last winter, and their opponents, concerned in limiting road taxes to road improvements, were prepared to voice only general objections. The roadbuilders as a consequence now have the tremendously difficult task of fighting to reverse an accomplished legislative act.

With the necessity clearly realized, the men concerned in roadbuilding in New York have organized and mobilized their forces with admirable speed and judgment. Possibly there would have been no raid on roadbuilding funds had as perfect a fighting body existed to repel the first attack. Roadbuilders throughout the country have in this thought a lesson of vital importance, for motor-vehicle taxes are too tempting a prize to escape constantly increased attacks.

Model Tests Confirm Design of Hoover Dam

Deflections and strains of plaster-celite model under mercury loading measured with high precision—Results confirm the design analysis closely

By J. L. Savage and Ivan E. Houk

Chief Designing Engineer and Senior Engineer, Bureau of Reclamation, Denver, Colo.

INTENSIVE STUDY to assure unquestioned safety and stability of a dam has never been more imperative than in the case of the Hoover Dam, nearly twice as high as its nearest competitor. Will it be safe? Model tests here reported give a thoroughly reassuring answer. They are still continuing, for various auxiliary questions are yet to be examined, but the main issue is clearly disposed of by the investigations that Messrs. Savage and Houk set forth. Question has been raised concerning the value of model tests. Extensive data are now available from the work on Stevenson Creek, Gibson and Hoover dams. Both calculation and large-scale tests verify the model results with high precision. The authors are able to state positively that the model investigations give dependable proof of safety. —EDITOR.

EXTENSIVE TESTS of a model of Hoover Dam have been carried out by the Bureau of Reclamation at the University of Colorado in cooperation with the Engineering Foundation arch dam committee. They give a remarkably close check on the results of the design calculations, and, while not yet complete, have already set at rest the principal questions affecting the design.

Model tests of arch dams, begun two years ago, were instituted primarily for the purpose of developing methods that might later be used in determining an adequate and safe design for Hoover Dam. The preliminary tests, confined to concrete models of Gibson Dam and the Stevenson Creek test dam, were eminently satisfactory. The tests of the plaster-celite model of Hoover Dam, now rapidly approaching completion, are also satisfactory.

Design of dam found safe

The results of the tests and related investigations thus far, including the tests of the Gibson and Stevenson Creek test dam models as well as the Hoover Dam model, have led the writers to the following general conclusions:

1. The massive arch-gravity design for Hoover Dam included in the contract drawings is logical, adequate and entirely safe for all conditions of load.

2. Only a few minor modifications in horizontal curvature and a few slight changes in the slopes of the edges of the cantilever elements may be found desirable in the final plans.

3. There is no question but that arch action will develop in Hoover Dam during the filling of the reservoir, long before the reservoir water surface rises to such a level as to approximate full-load conditions.

4. The distribution and magnitude of stress in Hoover Dam, both empty and full, will be substantially as calculated by the trial-load method.

5. The trial-load method of analysis accurately determines the deflections of arch and arch-gravity dams during the application of the live load in so far as accurate information may be available regarding the values of the modulus of elasticity for the concrete in the dam and the rock in the foundation and abutment formations.

6. The construction and testing of accurate models of arch dams furnish a satisfactory and reliable basis for checking the action and safety of full-size dams.

7. Foundation and abutment deformations are especially important in massive arch-gravity dams of the proportions of Hoover Dam. They must be properly allowed for in technical studies of the action of the dam if reliable results are to be secured. They cannot be considered negligible at comparatively shallow depth in the canyon walls.

Purpose of the tests

The model tests were planned primarily to determine the structural action of the dam and foundation during the filling of the reservoir. For this purpose it is not necessary that the ratio of the specific gravity of the loading liquid to that of the material in the model should equal the corresponding ratio in the prototype. Due to the dimensional similarity of the deflection equations the distribution of reservoir load between the arch and cantilever elements will be the same in the model as in the prototype, regardless of the density of the loading liquid and the physical characteristics of the materials used in building the two structures, assuming that the materials are elastic and that loads are transmitted by tensile forces wherever such forces develop.

The assumption regarding elasticity of materials can be easily and accurately fulfilled within the limits of the working stresses. The assumption regarding transfer of load by tensile forces is not critical in the case of Hoover Dam inasmuch as practically all loads are carried by compression. No tension at all will occur in the cantilever elements, and there will be only relatively small amounts in the arch elements. With practically all loads transmitted by compressive forces it is not necessary that construction joints in the prototype be reproduced in the model. However, the material selected for use in constructing the model has physical properties that permit the formation of vertical construction joints in the tension areas after the initial tests are completed, so that the effects of the opening of the joints in such areas can be determined by subsequent measurements. The model was built in horizontal layers, so that the laminations between layers correspond in a measure to horizontal construction joints in the dam.

It is obviously impossible to build and test a model of Hoover Dam and then wait until the full-size structure is completed and the measurement repeated on the prototype before determining whether or not the model procedure is satisfactory. The model tests must produce results without delay, in order that such results can be of value in improv-

Fig. 1—The slope of the canyon at the site of Hoover Dam was accurately reproduced in plaster before the model of the dam was built up. The scale is 1:240, or 1 in. in the model for 20 ft. in the dam.

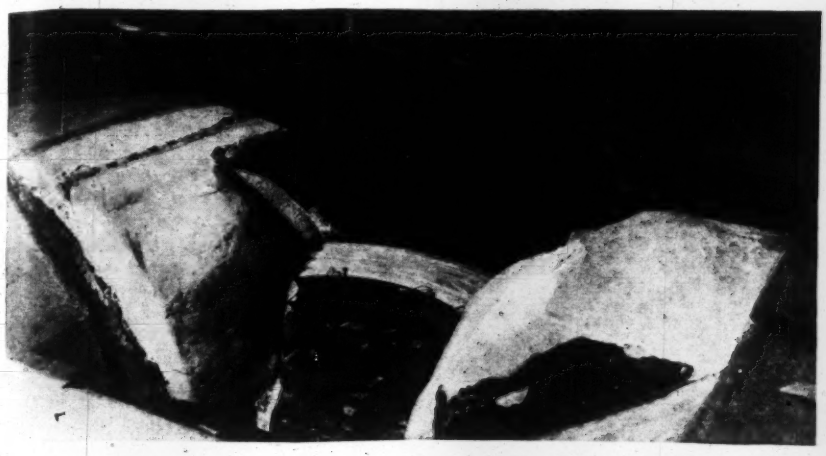


Fig. 2—A solid upstream form and sectional downstream forms were used in building up the model dam, here shown when poured to a height corresponding to El. 950. Horizontal joints between layers were notched with keyways and varnished before next layer was poured.

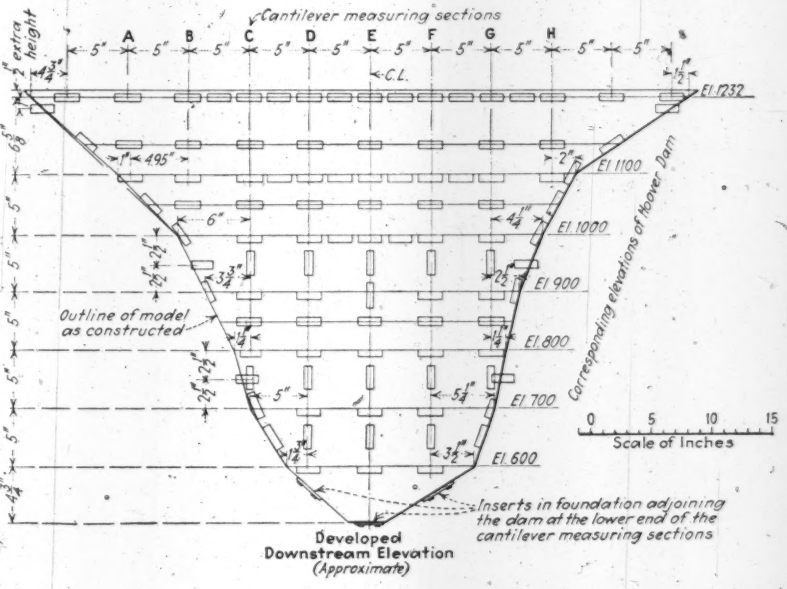
ing the design of the prototype. Consequently, the most logical procedure is to check the results of the model measurements, in as many ways as possible, against the theoretical methods being used in the technical design of the full-size structure.

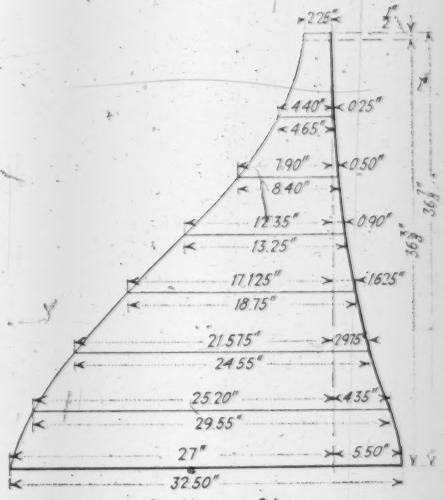
Thus the model problem was reduced to the determination of the sufficiency of the trial-load method of analysis. This method, which was developed in the Denver office of the Bureau of Reclamation, had previously been found to be satisfactory when checked against measurements on three different structures: the model of the Gibson Dam, the model of the Stevenson Creek test dam and the full-size Stevenson Creek test dam. Incidentally, this method of analysis makes proper allowances for the shape of the dam and the topography at the dam site as well as for the various stress conditions that take place within the structure and within the canyon rock constituting the foundation and abutments.

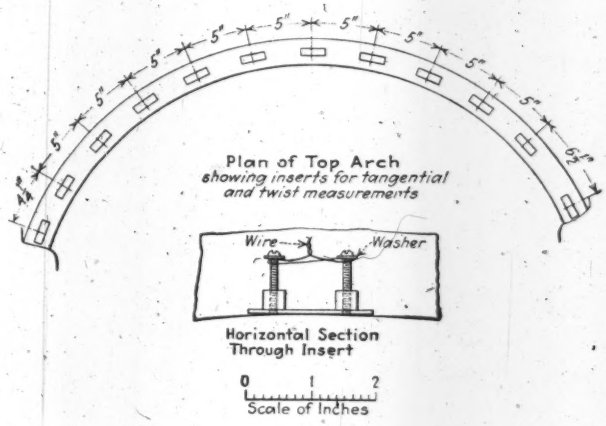
Material of the model

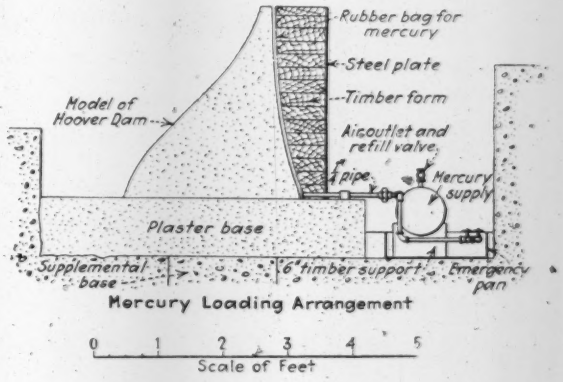
The selection of a suitable material for use in building a model of Hoover Dam was based on an exhaustive investigation of many possible materials: rubber, celluloid, bakelite, maizolith; various combinations of tar, pitch, resin, asphalt, litharge, and sulphur compounds; various mixtures of cement, asbestos, rubber, oil, and diatomaceous earth; and various mixtures of com-

Fig. 3—Hoover Dam test model, with inserts for measuring deflections and strains. To load the model dam, mercury was forced into a thin rubber bag placed between the upstream face of the dam and the timber form.









Model Tests Confirm Design of Hoover Dam

Deflections and strains of plaster-celite model under mercury loading measured with high precision—Results confirm the design analysis closely

By J. L. Savage and Ivan E. Houk
Chief Designing Engineer and Senior Engineer, Bureau of Reclamation, Denver, Colo.

INTENSIVE STUDY to assure unquestioned safety and stability of a dam has never been more imperative than in the case of the Hoover Dam, nearly twice as high as its nearest competitor. Will it be safe? Model tests here reported give a thoroughly reassuring answer. They are still continuing, for various auxiliary questions are yet to be examined, but the main issue is clearly disposed of by the investigations that Messrs. Savage and Houk set forth. Question has been raised concerning the value of model tests. Extensive data are now available from the work on Stevenson Creek, Gibson and Hoover dams. Both calculation and large-scale tests verify the model results with high precision. The authors are able to state positively that the model investigations give dependable proof of safety. —EDITOR.

EXTENSIVE TESTS of a model of Hoover Dam have been carried out by the Bureau of Reclamation at the University of Colorado in cooperation with the Engineering Foundation arch dam committee. They give a remarkably close check on the results of the design calculations, and, while not yet complete, have already set at rest the principal questions affecting the design.

Model tests of arch dams, begun two years ago, were instituted primarily for the purpose of developing methods that might later be used in determining an adequate and safe design for Hoover Dam. The preliminary tests, confined to concrete models of Gibson Dam and the Stevenson Creek test dam, were eminently satisfactory. The tests of the plaster-celite model of Hoover Dam, now rapidly approaching completion, are also satisfactory.

Design of dam found safe

The results of the tests and related investigations thus far, including the tests of the Gibson and Stevenson Creek test dam models as well as the Hoover Dam model, have led the writers to the following general conclusions:

1. The massive arch-gravity design for Hoover Dam included in the contract drawings is logical, adequate and entirely safe for all conditions of load.

2. Only a few minor modifications in horizontal curvature and a few slight changes in the slopes of the edges of the cantilever elements may be found desirable in the final plans.

3. There is no question but that arch action will develop in Hoover Dam during the filling of the reservoir, long before the reservoir water surface rises to such a level as to approximate full-load conditions.

4. The distribution and magnitude of stress in Hoover Dam, both empty and full, will be substantially as calculated by the trial-load method.

5. The trial-load method of analysis accurately determines the deflections of arch and arch-gravity dams during the application of the live load in so far as accurate information may be available regarding the values of the modulus of elasticity for the concrete in the dam and the rock in the foundation and abutment formations.

Fig. 1—The slope of the canyon at the site of Hoover Dam was accurately reproduced in plaster before the model of the dam was built up. The scale is 1:240, or 1 in. in the model for 20 ft. in the dam.

6. The construction and testing of accurate models of arch dams furnish a satisfactory and reliable basis for checking the action and safety of full-size dams.

7. Foundation and abutment deformations are especially important in massive arch-gravity dams of the proportions of Hoover Dam. They must be properly allowed for in technical studies of the action of the dam if reliable results are to be secured. They cannot be considered negligible at comparatively shallow depth in the canyon walls.

Purpose of the tests

The model tests were planned primarily to determine the structural action of the dam and foundation during the filling of the reservoir. For this purpose it is not necessary that the ratio of the specific gravity of the loading liquid to that of the material in the model should equal the corresponding ratio in the prototype. Due to the dimensional similarity of the deflection equations the distribution of reservoir load between the arch and cantilever elements will be the same in the model as in the prototype, regardless of the density of the loading liquid and the physical characteristics of the materials used in building the two structures, assuming that the materials are elastic and that loads are transmitted by tensile forces wherever such forces develop.

The assumption regarding elasticity of materials can be easily and accurately fulfilled within the limits of the working stresses. The assumption regarding transfer of load by tensile forces is not critical in the case of Hoover Dam inasmuch as practically all loads are carried by compression. No tension at all will occur in the cantilever elements, and there will be only relatively small amounts in the arch elements. With practically all loads transmitted by compressive forces it is not necessary that construction joints in the prototype be reproduced in the model. However, the material selected for use in constructing the model has physical properties that permit the formation of vertical construction joints in the tension areas after the initial tests are completed, so that the effects of the opening of the joints in such areas can be determined by subsequent measurements. The model was built in horizontal layers, so that the laminations between layers correspond in a measure to horizontal construction joints in the dam.

It is obviously impossible to build and test a model of Hoover Dam and then wait until the full-size structure is completed and the measurement repeated on the prototype before determining whether or not the model procedure is satisfactory. The model tests must produce results without delay in order that such results can be of value in improv-

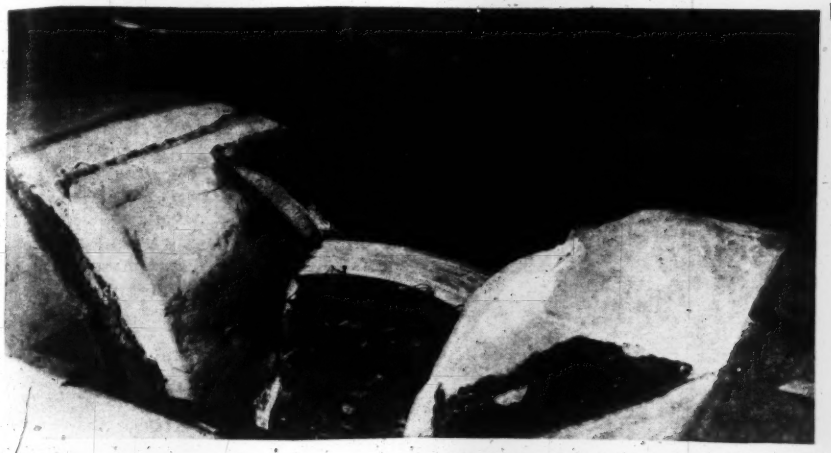


Fig. 2—A solid upstream form and sectional downstream forms were used in building up the model dam, here shown when poured to a height corresponding to El. 950. Horizontal joints between layers were notched with keyways and varnished before next layer was poured.

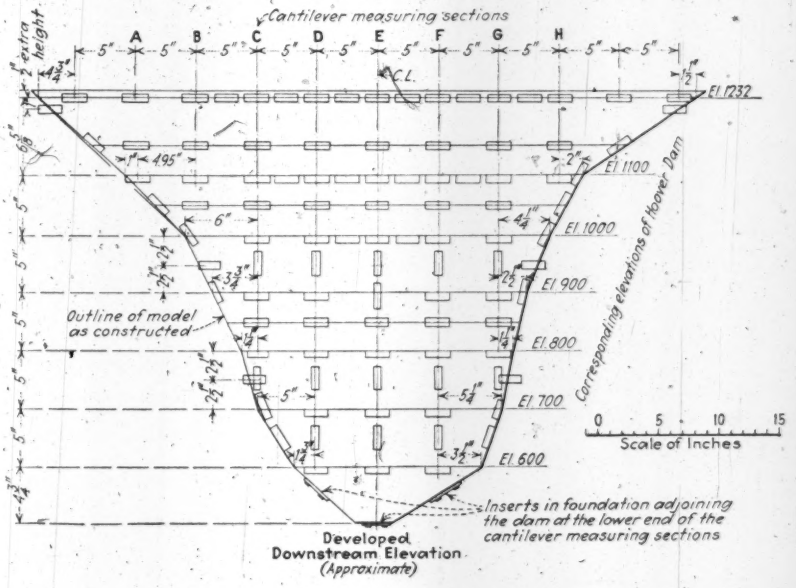
ing the design of the prototype. Consequently, the most logical procedure is to check the results of the model measurements, in as many ways as possible, against the theoretical methods being used in the technical design of the full-size structure.

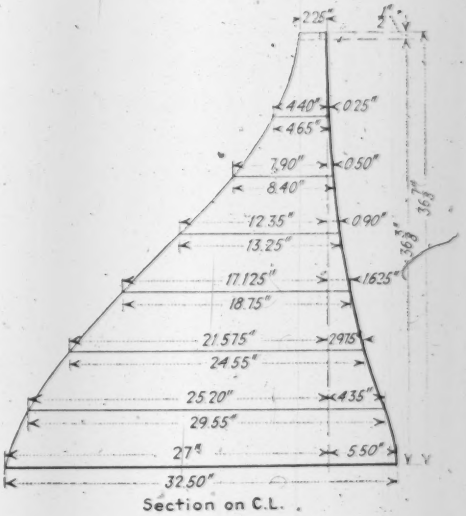
Thus the model problem was reduced to the determination of the sufficiency of the trial-load method of analysis. This method, which was developed in the Denver office of the Bureau of Reclamation, had previously been found to be satisfactory when checked against measurements on three different structures: the model of the Gibson Dam, the model of the Stevenson Creek test dam and the full-size Stevenson Creek test dam. Incidentally, this method of analysis makes proper allowances for the shape of the dam and the topography at the dam site as well as for the various stress conditions that take place within the structure and within the canyon rock constituting the foundation and abutments.

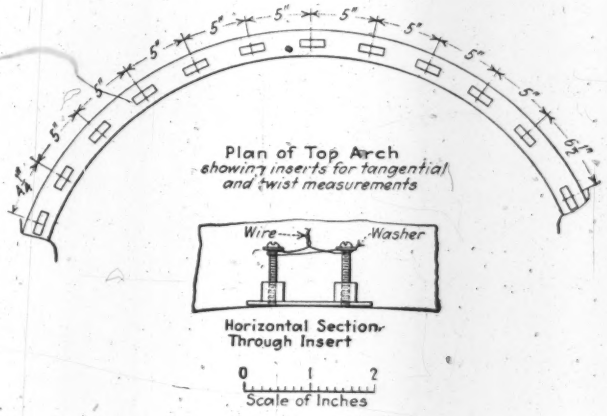
Material of the model

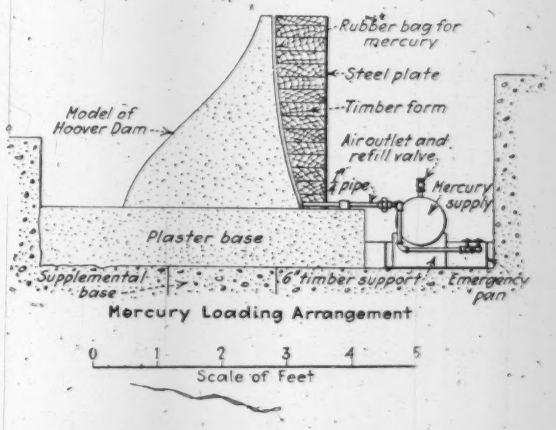
The selection of a suitable material for use in building a model of Hoover Dam was based on an exhaustive investigation of many possible materials: rubber, celluloid, bakelite, maizolith; various combinations of tar, pitch, resin, asphalt, litharge, and sulphur compounds; various mixtures of cement, asbestos, rubber, oil, and diatomaceous earth; and various mixtures of con-

Fig. 3—Hoover Dam test model, with inserts for measuring deflections and strains. To load the model dam, mercury was forced into a thin rubber bag placed between the upstream face of the dam and the timber form.









PHYSICAL PROPERTIES AND PRINCIPAL DIMENSIONS FOR BOTH MODEL AND PROTOTYPE OF HOOVER DAM

Physical Properties	Unit	Model	*Prototype	Ratio Prototype to Model
Modulus of elasticity in compression	Lb. per sq.in.	90,000	5,500,000	61.1
Modulus of elasticity in tension	Lb. per sq.in.	100,000	5,500,000	55.5
Shearing modulus	Lb. per sq.in.	45,000	833,000	18.5
Poisson's ratio		0.20	0.20	1.0
Maximum allowable stress in compression	Lb. per sq.in.	80	420	5.2
Maximum allowable stress in tension	Lb. per sq.in.	15	60	4.0
Ultimate strength in compression	Lb. per sq.in.	200	2,500	12.5
Ultimate strength in tension	Lb. per sq.in.	25	300	12.0
Weight per cubic foot	Lb.	41.8	150	3.6
Maximum allowable moisture content	Per Cent	4.0		
Coefficient of thermal expansion	Per deg. F.°	0.000011	0.0000056	0.5
Flow under 40 lb. per sq.in. compression	In./in.	0.000108†	.....	....
Flow under 20 lb. per sq.in. tension	In./in.	0.000062†	.....	....
Dimensions				
Length at top	In.	56.0	1,120	240
Thickness at top	in	2.25	45	240
Maximum height	model,	36.3	727	240
Thickness at base of maximum section	ft. in	32.5	650	240
Radius of curvature, upstream face at top	dam	25.0	500	240

*Physical characteristics used in technical design studies or estimated values included for comparison.
†Total at end of 21 days; about half of this flow occurs during first half day.

mercial building plasters, lime and celite. Mixtures of plaster, diatomaceous earth and water were most promising. Detailed experiments on several hundred test specimens mixed in different proportions were then made for the purpose of studying workability, uniformity of mix, time of setting, compressive and flexural strength, modulus of elasticity, Poisson's ratio, bonding of successive layers of material, bonding of material to metal inserts, unit weights and rates of evaporation.

The material finally selected was a combination of Acme finishing plaster, celite (diatomaceous earth) and water, the ingredients being mixed in the proportions of 1 lb. plaster to 0.5 lb. celite and 1.875 lb. water. The temperature of the mixing water was generally kept at or below 60 deg. F., but when it was higher from one to four level teaspoonfuls of Aquagel were added to each 24 lb. of plaster in order to retard the set so that the batch could be placed before the mixture became too stiff to handle.

The conditions that governed the selection of the material, in the order of their relative importance, were as follows:

1. The model was to be built and tested in the testing pit already constructed in the basement of the testing laboratory at the University of Colorado, Boulder, Colo.

2. The model must be uniformly elastic within the range of maximum working stresses occurring during the full-depth mercury load tests.

3. The modulus of elasticity must be low enough that the deformations under full-depth mercury loading will be susceptible of accurate measurement with available testing equipment.

4. Poisson's ratio must be about the same as for concrete.

5. The material must not shrink or swell after being poured into the forms.

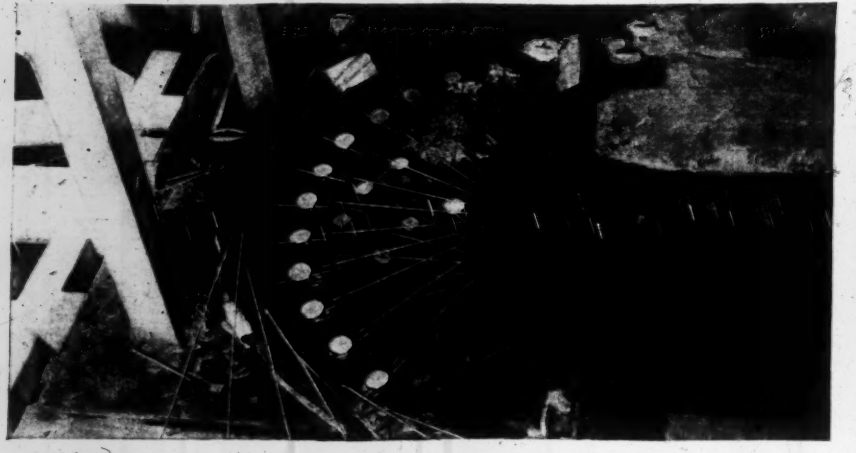
6. The ratio of the ultimate strength of the material to the ultimate strength of concrete should be about the same for both compression and tension.

7. The material must be easily obtainable in the quantities needed, easily workable in both wet and dry states and susceptible of being dried after being placed in the forms.

8. The coefficient of thermal expansion must be uniform and preferably much larger than in the case of concrete.

All of the above-listed conditions, except 7, are satisfactorily met. The material is easily obtainable and easily workable, but it is rather slow in drying, so that the construction and drying of a model of the shape of Hoover Dam is a rather tedious process. The above table gives the more important physical characteristics of the selected materials, also the principal dimensions for both model and prototype.

Fig. 4—Invar rods and dial gages reading to one ten-thousandth inch were attached to the model for measuring radial and tangential deflections.



The model was built on a scale of 1 240; that is, 1 in. in the model corresponds to 20 ft. in the dam. Fig shows a cross-section of the model the crown, a developed downstre elevation and a plan of the top a The locations at which metal ins were placed at the downstream face, use in measuring strains and deflecti are shown on the developed elevat The model was built ½ in. higher t the elevation corresponding to the of the dam, in order to provide adequ cover for the top row of inserts. additional row of inserts, for use measuring tangential and twist deform tions of the top arch, was placed alo the top of the model, as shown in t plan view of the top arch.

The elevation in Fig. 3 does not sh the plaster foundation and abutments. plaster-and-celite model of the canyo with a minimum thickness of 12 in., w built against the concrete walls a floor of the testing pit and thoroughl dried before the model of the dam w constructed. The canyon walls wer built up in layers 3 in. thick, and t model dam was built in layers 2½ i thick. Each layer was dried by blowin heated air over the surface of th plaster until samples from the center o the layer showed a moisture content no exceeding 4 per cent. The surface o the dried layer was provided with key ways to furnish satisfactory strengt against failure by shear at the con struction joints; then it was painted with two coats of shellac and one coat of varnish to prevent the absorption o moisture after the next layer wa poured. Thermocouples, for use in mea suring the interior temperature, were placed in the plaster at the time o

Fig. 5—Strains on the downstream face were measured in vertical, horizontal and diagonal directions by dial gages connected to gage rods. Here the gages are shown as placed for measuring one set of diagonal strains.

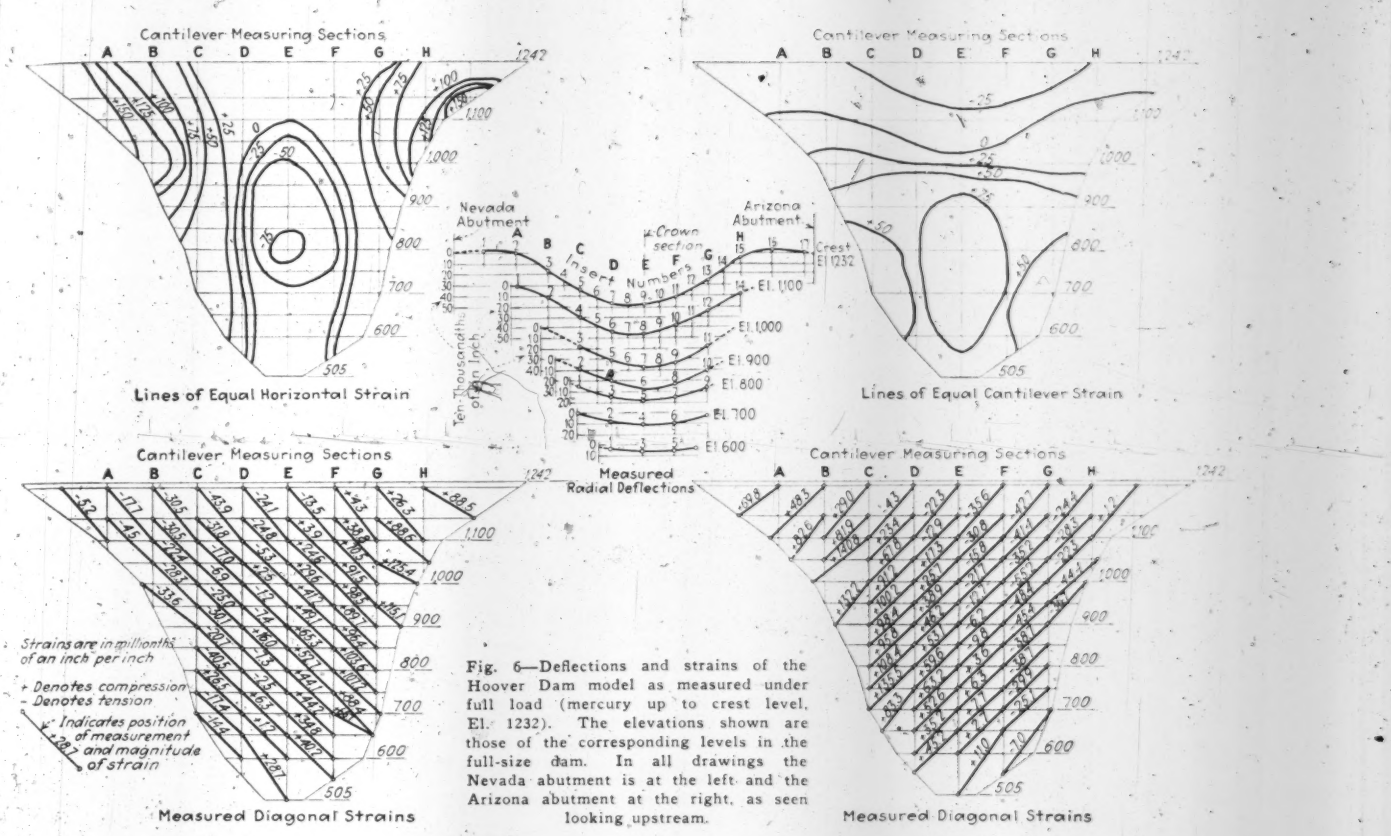


Fig. 6—Deflections and strains of the Hoover Dam model as measured under full load (mercury up to crest level, El. 1232). The elevations shown are those of the corresponding levels in the full-size dam. In all drawings the Nevada abutment is at the left and the Arizona abutment at the right, as seen looking upstream.

pouring; and suitable test specimens, for use in determining the physical characteristics of the mixture, were taken from each layer of the canyon and model-dam materials.

An accurate model of the canyon, built of timber, wire netting and plaster, was used as a form in pouring the final layer of the foundation and abutments. Laminated timber forms, built of the best grade of white pine, were used at the upstream and downstream faces of the model. The upstream form was assembled, placed in position and allowed to remain undisturbed until the model was completed. The downstream form was assembled, layer by layer, as the model was built.

Methods of testing

The mercury load was applied to the model through a rubber bag (Fig. 3) held in place at the upstream face of the model by the upstream form, which latter was braced against the concrete walls and ceiling of the testing pit. The mercury was forced into the rubber bag by city water pressure applied at the top of the mercury supply tank.

The tests have been grouped primarily in three series: (1) deflection tests, in which radial, tangential and angular deformations were measured at several elevations; (2) deformation tests, in which the movements of the foundation and abutments and the spreading of the canyon walls were measured at several elevations; and (3) tests in which the strains at the downstream face of the model were measured in vertical, horizontal and diagonal directions. In addition, a great many special tests were made, for determining interior stresses near the downstream face, differences between radial deflections at the center lines of the arches and at the downstream face, etc.

All deformations except twisting were measured with 0.0001-in. measuring dials. Angular movements were measured by means of an optical lever system, the reflection of an engineer's scale in optical flats mounted on the model being read with a transit set on a concrete post in the corner of the laboratory.

In the deflection tests, radial invar rods (Fig. 4) were attached to small inserts at the downstream face of the model; and the movements of the model were measured with reference to a steel and concrete post. The maximum deflection of the model under the full-depth mercury load was about 0.005 in., or about 50 scale divisions on the dials. Tangential deflections of the arch elements were measured in a similar manner. At the top of the model the tangential deflections were measured along the center line of the arch; at lower elevations they were measured at the downstream edge of the arch. Deformations of the foundation and spreading of the abutments at the ends of the arch and cantilever elements were measured in 36 different places. These measurements varied from zero to about one-fourth the radial and tangential deflections of the arch elements. Strains at the downstream face were measured between inserts 5 in. apart in the case of the vertical and horizontal measurements, and 7 in. apart in the case of the diagonal measurements (Fig. 5).

Resumé of tests

Thus far, about 700 different loadings have been applied to the model. With the exception of a few preliminary tests that were made under a water load, all tests have been made under mercury pressure. The tests have included many part-load tests and many overload tests, as well as many full-load tests, the full-load tests being those in which the surface of the mercury in the rubber bag corresponded to the elevation at the top of the prototype (El. 1232). The maximum elevation of the mercury surface in the overload tests corresponded to an elevation of 1,400 ft. at the dam, a height of 168 ft. above the crest of the structure. The surface of the mercury in the various part-load and overload tests was varied by increments corresponding to 50-ft. heights at the dam, beginning with a minimum elevation of 1,100 ft.

A large number of the tests included in the 700 mentioned were simply check tests to establish the accuracy of the various dial readings. Others were repeat tests to determine special effects. For instance, after the testing work

was started it was found desirable to make slight alterations in the plaster walls near the dial supports, to smooth and extend the canyon walls upstream from the model dam, and to apply mercury pressure to the two sides of the canyon to simulate reservoir pressure on the sides of the canyon upstream from the prototype.

Plans for future work contemplate a series of temperature tests to determine the effect of contraction in the arch elements during a drop in the interior temperature of the dam. In these tests the model probably will be cooled by circulating cold air, or possibly carbon dioxide vapor, along the upstream and downstream faces. Temperatures in the interior of the model will be measured with thermocouples embedded in the model at the time of its construction. After the temperature tests are completed vertical construction joints will probably be cut into the model at the locations where arch tension is indicated, and enough full-depth mercury load tests will be repeated to determine the effects of such open joints. It may also be found desirable to make slight modifications in the slopes of the cantilever faces and in the curvature of the higher arch elements, and then to apply full-depth mercury tests on the modified structure. Changes of a minor nature can be made easily in the model by simply trimming off excess plaster or adding new material as the case may be.

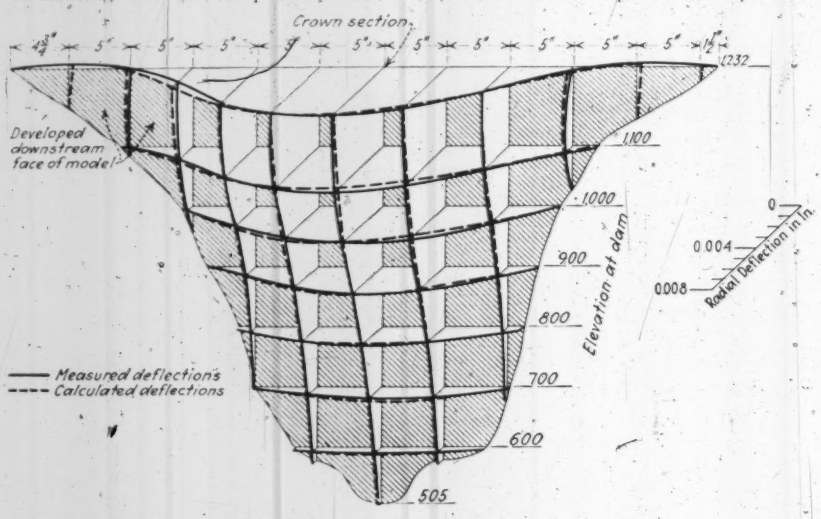


Fig. 7—Deflections measured on the model checked the calculated deflections very closely. The measured deflections are those of test 85, made with full mercury load (to El. 1232). The calculated deflections were computed by the trial-load method on the basis of a modulus of elasticity of 90,000 lb. per sq.in. and density of mercury 13.6, and were corrected from center line to downstream face.

Results of tests

Naturally, the results of the tests are too voluminous to be more than briefly presented in an article of this nature. Since the action of the model under the normal full-load tests is probably the most important phase of the work, the discussions will be confined to the tests made with mercury surface corresponding to the top of the dam (El. 1232).

Fig. 6 shows the radial deflections of the arch elements measured during test No. 85, a typical full-load test. Other plottings in the same figure show the lines of equal horizontal and vertical strains measured at the downstream face of the model under full load, and the actual strains measured in diagonal directions. The dotted portions of the deflection curves represent interpolations at locations where actual measurements were not feasible.

It will be seen that smooth deflection curves were obtained at all elevations. The curves show a slight upstream deflection near the abutments of the top arch, a slight lack of symmetry about the crown section, and downstream deflections at the abutments of the lower arches somewhat greater at the Arizona abutment than at the Nevada abutment. The upstream deflections near the abutments of the top arch were to be expected; such movements are frequently indicated in analyses of the upper elements of arch dams, and similar movements were measured at the Stevenson Creek test dam, in both prototype and model, and in the model of the Gibson Dam. The lack of symmetry on the two sides of the crown section is accounted for partly by the lack of symmetry at the dam site and partly by the slightly greater downstream deflections at the Arizona ends of the lower arches. The slightly greater downstream deflections at the Arizona abutments are partly due to the somewhat greater total horizontal pressure on the Arizona side of the crown section and partly to a minute hair crack between the concrete and plaster materials at the Arizona abutment.

In the diagram of horizontal strains an area of horizontal tension appears near the crown at the lower elevations such as is frequently indicated in the analyses of arch dams. The lines of equal strain also show a building up of compressive forces near the abutments in the upper arches, thus indicating that it may be desirable to increase the thickness of the arches at these locations. All vertical strains at the downstream face are seen to be compressive except in a small area at the upper elevations near the crown sections. The tensile strains indicated are due to the comparatively light weight of the plaster-and-celite material; they are not indicated by the trial-load analysis for the prototype.

Areas of diagonal tensile strains are found at the downstream face near the abutments. The maximum tensile stress indicated by the negative strains is only about 5 lb. per sq.in., or only about one-third of the maximum allowable tensile stress for the plaster-and-celite material and only about one-sixth of the ultimate strength in tension. Somewhat higher tensile strains were produced during the overload tests, but so far as can be determined by a very careful examination, no cracking has taken place in the model of the dam or in the plaster abutments at either upstream or downstream face.

Minute hair cracks have occurred between the concrete and plaster materials at the boundaries of the plaster abutments in a few segregated locations, as mentioned above; but there has been no indication of a failure by shear or by sliding, although the sliding factor for the model as a whole is 4.72 for the normal full-load tests and 5.74 for the maximum overload test. Of course this simply bears out what engineers conversant with arch-dam design have long known: namely, that sliding-factor calculations are not pertinent in the case of arch dams. The unusually high sliding factor for the model is due to the relatively low specific gravity of the plaster material and the relatively high specific gravity of the loading liquid. The sliding factor for the full-size Hoover Dam, computed for the structure as a whole and making adequate allowance for uplift, is 0.60.

Comparison with trial-load analysis

A direct comparison of the radial deflections measured during test 85 with the calculated deflections is given graphically in Fig. 7. Full lines represent measured deflections, dotted lines the calculated deflections. In the case of the lower arches the trial-load calculations, which determine radial deflections at the center lines of the arches, were corrected so as to give deflections at the downstream face of the model, this correction being necessary because of the relatively great thickness of the material at the lower elevations. The correction was calculated on the basis of the elasticity of the material, and the calculations were

later checked by actual measurements on the model. The calculations of foundation and abutment deformations included in the trial-load analysis were adjusted to conform to the actual depths of plaster in the canyon walls and to the irregularities in topographical conditions at the dam site, the adjustments being made on the basis of actual measurements on the model.

The trial-load analysis included the effects of tangential shear, radial shear, twist, and radial sides of cantilever elements, as well as the usual effects of bending moment and thrust; but it did not include the effects of a Poisson's ratio adjustment. The Poisson's ratio adjustment would not have an important bearing on the comparison in this case, since the value of Poisson's ratio for the model materials is only about 0.20, and also because the general effect of the Poisson's ratio adjustment is toward an evening up of the arch and cantilever stresses at the crown cantilever without causing important changes at the abutments. The final investigations will include this adjustment.

The curves in Fig. 7 show that the calculated data agree very closely with the measured data. The calculated deflections are slightly greater than the measured deflections at the three lower arches, but they cross back and forth over the measured curves at the higher arches, never diverging from the measured curves by any appreciable distances. Curves at cantilever elements show similarly satisfactory agreements. On the whole the agreement is even more satisfactory than those obtained for the models of the Gibson and Stevenson Creek test dams and the full-size Stevenson Creek test dam.

Interpretation of model data

There are only two appreciable uncertainties involved in the correlation between the action of the model and the prototype under live-load conditions. These are: first, the lack of satisfactory data regarding the value of the modulus of elasticity for the full-size dam and the full-size canyon; and, second, the possibility and extent of cracking in tension areas. Uplift pressure, which is so important a factor as regards the stability of a gravity dam against failure by sliding, is not an important factor in the action of an arch-gravity dam, where a large proportion of the live load is carried by arch action.

It is believed that the detailed investigations now under way by the Bureau of Reclamation in connection with the design of Hoover Dam will throw much light on the modulus of elasticity problems. Cracking in the tension areas is not an important factor in the case of Hoover Dam, inasmuch as there will be no tension in the vertical elements at any location in the structure. Vertical compressive stresses at the upstream face of the dam are greater than those at the downstream face at all elevations. They are also greater than the water pressure; so that no tension can occur in the concrete even if full uplift pressure should occur in the pores of the concrete or in the horizontal construction joints. Tension in the horizontal elements will be relieved by a slight opening of the vertical construction joints, the tensile forces indicated by the calculations being carried by a slight increase in the horizontal compression at the downstream face, which is well within safe limits at all elevations. Consequently there is no reason to doubt the applicability of the model results and the trial-load analysis as regards the action of Hoover Dam.

The question of horizontal cracking in the areas of calculated vertical tension in a dam is much more important than the question of vertical cracking in the areas of calculated horizontal tension, due to the differences in the methods of construction. Horizontal construction joints are thoroughly cleaned and covered with grout before beginning a new layer of concrete. Consequently some tension may be carried across the horizontal joints. Whether this will be 25 lb. per sq. in. or 100 lb. in any particular dam is not known. Probably it will be different at different points and in different parts of a dam. On the other hand, vertical construction joints are made in such a way as to reduce the possibility of any appreciable tensile forces being transferred across the joints; so that the assumption that all horizontal forces are carried by compressive stresses is believed to be well founded.

Since vertical tension is much more commonly indicated in thin arch dams than in massive arch-gravity dams, it seems certain that model results and trial-load analyses are more accurate indications of the action of the prototype in the case of the massive type than in the case of the thin dam. This was indicated by the results of the tests of the model and the prototype of the Stevenson Creek test dam. The model loaded with water did not give a satisfactory indication of the action of the prototype because the stresses were not large enough to produce similar conditions of cracking. As soon as the model was loaded with mercury and similar cracks were produced, the model measurements furnished a satisfactory check on the action of the full-size structure.

Consequently, the results obtained in the various model tests of arch dams, together with the trial-load analyses and related technical studies conducted by the Bureau of Reclamation, have convinced the writers that the accurate construction and proper testing of models of arch dams furnishes a satisfactory indication of the action of full-size arch dams under load.

Acknowledgments

The model tests of Hoover Dam are being made by a corps of engineers working under the direct supervision of A. W. Simonds, engineer, and under the general direction of Ivan E. Houk, senior engineer. All designing studies and investigations are made under direction of J. L. Savage, chief designing engineer. All engineering and construction work of the bureau is under the general direction of R. F. Walter, chief engineer, with headquarters at Denver; and all activities of the bureau are under the general charge of Dr. Elwood Mead, Commissioner of Reclamation, with headquarters at Washington, D. C.

Major Changes Made in Engineer License Law in New York State

AMENDMENTS to the education law of the state of New York as it affects the practice of professional engineering, land surveying and architecture were passed by the state legislature at its recent session and became law on March 29 when signed by the governor. The changes are the result of a very detailed study of the two laws by representatives of the professions and of the department of education. The study was directed toward two ends: first, that of eliminating causes of friction between the professions of architecture and engineering; and second, clarification of the laws and improvement of the machinery for administering and enforcing them.

Many of the changes made are minor ones relating to administration or enforcement or are changes designed to make the two laws as nearly uniform as possible. They are of purely local interest. Other changes, however, are significant as indicative of trends in license laws; they are given in full in subsequent paragraphs.

Difficulties due to overlap

Overlapping of the professions of engineering and architecture, chiefly in the building field, has been the chief cause of controversy between the two professions and has resulted in holding up needed changes in the engineers' law through the ability of architects to block the passage of amendments that did not meet with their approval. The most

needed change in the engineers' law was inclusion of a proper definition of engineering, specifically one that would make it clear that engineering included building design; because architects, through interpretations placed on their law and through the wording of section 300 of the multiple-dwelling law, had succeeded in placing a serious check upon the practice of engineers in the building field. To correct this situation, architects suggested segregation of the men who practice in the building field by a special certification as "structural engineers." They justified the segregation on the ground that all engineers were not trained in the fundamentals of building design and so should not be granted the legal right to do building work. Engineers opposed the segregation as unnecessary and highly undesirable; also they maintained that with the higher educational standard to be required of all engineers after 1937 (written into the law in 1931) all engineers would have structural training equal or superior to that required of architects.

Agreement on how to settle this issue to the satisfaction of both sides was reached in February of this year. The term "building" is included in the definition of engineering in the revised law and, in addition, to meet the objection of architects, the following has been added to the section relating to examination of applicants for license:

> Nothwithstanding anything herein contained, every applicant for license as professional engineer, otherwise required to take an examination, shall be required, in addition to other requirements, to establish by written examination his competency to plan, structurally design and supervise the construction of buildings and similar structures.

The definitions of a professional engineer and of a land surveyor, of professional engineering and of land surveying in the amended license law, are as follows:

> "Professional engineer" means a person who engages in the practice of professional engineering as hereinafter defined.
>
> "Land surveyor" means a person who engages in the practice of land surveying as hereinafter defined.
>
> A person practices professional engineering, within the meaning and intent of this article, who holds himself out as able to perform, or who does perform any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works or projects, wherein the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of engineering principles and data.
>
> A person practices land surveying within the meaning and intent of this article who surveys areas for their correct determination and description, and for conveyancing, or for establishment or re-establishment of land boundaries and the plotting of lands and subdivisions thereof.

The practice of architecture, as defined in the amended law, is as follows:

> A person practices architecture within the meaning and intent of this article, who holds himself out as able to perform or who does perform any professional service such as consultation, investigation, evaluation, planning, design, including esthetic and structural design, or responsible supervision of construction, in connection with any private or public buildings, structures or projects, or the equipment or utilities thereof, or the accessories thereto, wherein the safeguarding of life, health or property is concerned or involved, when such professional service requires the application of the art and science of construction based upon the principles of mathematics, esthetics and the physical sciences.

That the two professions do overlap and that members of either may practice in the undefined common zone is further recognized by "saving clauses" in each law exempting licensees of the other professions.

Unlawful practice

What constitutes unlawful practice of professional engineering has been restated to make it more clear that holding oneself out to be a professional engineer constitutes violation of the law. The section relating to unlawful practice now reads:

> It shall be unlawful for any person to practice or to offer to practice professional engineering or land surveying in this state or to use the title professional engineer or land surveyor, or any title, sign, card or device to indicate that such person is practicing professional engineering or land surveying or is a professional engineer or land surveyor, unless such person has been duly licensed under the provisions of this article.

The same section also has been expanded by addition of the following:

> No official of this state, or of any city, town or village therein, now or hereafter charged with the enforcement of laws, ordinances or regulations relating to the construction or alteration of buildings or structures, shall accept or approve any plans or specifications that are not stamped with the seal of a licensed architect or licensed professional engineer.

Educational requirements

Amendments made to the law last year set up specific educational requirements and made examinations obligatory after 1937 for all except "applicants who are possessed of long-established and recognized standing in the engineering profession." This exemption is retained in the law, but other exemption provisions and the provisions relating to applicants subsequent to 1937 have been altered to read:

> Upon the recommendation of the board the department may exempt from examination an applicant for license as professional engineer who holds a license or certificate to practice professional engineering issued to him upon examination by a legally constituted board of examiners in any other state or political subdivision of the United States, or who holds a certificate of qualification issued by the national council of state boards of engineering examiners, provided the requirement for such license or certificate was the full equivalent of the requirement in this state at the time it was issued, and provided, further, that the applicant's record fully met the requirement of this state in all respects other than examination.
>
> Every person applying subsequent to Jan. 1, 1937, for a license as professional engineer shall be required to pass the examination, and before admission thereto shall submit evidence that he has graduated from a college or school of engineering registered by the department as maintaining satisfactory standards. He shall also submit before admission to the examination evidence of practical experience in professional engineering work of a grade and character satisfactory to the board. Each complete year of study in the registered college or school of engineering may be accepted in lieu of one year of such experience and the applicant must submit evidence of sufficient additional experience to give him a total of eight years. In lieu of such graduation, an applicant may be admitted to the examination upon presenting evidence of at least twelve years of practical experience in professional engineering work of a grade and character satisfactory to the board.

To the list of exemptions from the provisions of the engineer license law as it stood at the time of revision, the following has been added. A corresponding clause has been added to the architects' law.

> Any person licensed as an architect under the laws of this state, except that such person shall not use the designation engineer or engineering unless licensed under the provisions of this article.

The section exempting officers or employees of corporations engaged in interstate commerce has been expanded to include other public service organizations. It now reads:

> Practice of professional engineering or land surveying, exclusively as an officer or employee of a public service corporation by rendering to such corporation such service in connection with its lines and property which are subject to supervision with respect to the safety and security thereof by the public service commission of this state, the interstate commerce commission or other regulatory body and so long as such person is thus actually and exclusively employed and no longer.

Changes in the sections of the law relating to architects provide for licensing of architects (instead of registering as at present) so that members of both professions now are licensed. Hereafter the licenses of members of both professions are required to be registered annually instead of renewed. This change preserves the use of the term "registered architect" and makes it possible for engineers who object to the use of the term "licensed" to use the term "registered professional engineer."

Concrete Mat Foundation for Car Tracks

Long service with practically no track or pavement maintenance has justified the higher cost of an unusually heavy street-car-track construction used in Columbus, Ohio. This construction, described by R. H. Simpson, city engineer, in a paper before the American Road Builders Association, consists of a concrete slab 8 in. thick as a sub-base for all track construction. This slab bridges over any weakness in the soil and prevents groundwater from reaching the track structure and pavement base. The track consists of 122-lb. 7-in. grooved rail bolted to 4-in. Carnegie steel ties, and it is laid on top of this concrete slab. It is then brought to proper grade and held in position by blocks under the ties, leaving a space of about 2 in. between the top of the slab and the under side of the ties. After being brought to proper alignment, concrete is placed under and around the ties and up on the rail about 2 in. This concrete, which holds the track firmly in position and acts as a base for the paving surface, rests on the sub-base slab but is not bonded to it. The track can therefore be readily removed and renewed without disturbing the sub-base slab. Granite block and brick surfaces have been used in car-track areas for the past twenty years.

Streamflow from Rainfall by Unit-Graph Method

Observed runoff following isolated one-day rainfall forms basis of computation—Method applicable to rainfalls of any intensity or duration

By L. K. Sherman
Consulting Engineer, Randolph-Perkins Co., Chicago, Ill.

BY MAKING USE of a single observed hydrograph, one due to a storm lasting one day, it is possible to compute for the same watershed the runoff history corresponding to a rainfall of any duration or degree of intensity. From the known hydrograph the "unit" graph must be determined, representing 1 in. of runoff from a 24-hour rainfall. The daily ordinates of the unit graph can then be combined in accordance with the variation in daily precipitation figures so as to show the runoff from a storm of any length.

Following a storm, the hydrograph representing the flow in the main-stream channel shows the runoff increasing to a maximum point and then subsiding to the value it had before the storm. For a single storm the graph is generally of a triangular shape, with the falling stage taking never less and usually two or more times as long as the rising stage. For the same drainage area, however, there is a definite total flood period corresponding to a given rainfall, and all one-day rainfalls, regardless of intensity, will give the same length of base of the hydrograph.

If a given one-day rainfall produces a 1-in. depth of runoff over the given drainage area, the hydrograph showing the rates at which the runoff occurred can be considered a unit graph for that watershed. As the area under a hydrograph for any time period represents the total volume of runoff in that time, it follows that the area under the unit graph, if expressed in inches of depth over one square mile, or inch-miles, is numerically equal to the area of the watershed.

Determining the unit graph

Based on these laws it follows that for any observed rainfall, during a unit of time, the ordinates of runoff vary directly with the depth of runoff on the drainage area. For example, let there be an observed hydrograph of runoff due to rainfall of 3 in. during a unit of time of one day, over a drainage area of 1,000 square miles. Measurement of the area of this hydrograph shows 2,000 inch-miles of runoff. The volume of rainfall, however, is 3,000 inch-miles. Therefore, the runoff is 66⅔ per cent, or 2 in., and the observed graph represents a 2-in. runoff applied in 24 hours. The unit graph for this area, then, is one having the same base but ordinates one-half as great as those on the observed graph. This is the procedure for determining a unit graph for any drainage area. The graph is a constant for any particular drainage area, but drainage areas of different physical characteristics give radically different forms.

A topography with steep slopes and few pondage pockets gives a graph with a high sharp peak and a short time period. A flat country with large pondage pockets gives a graph with a flat rounded peak and a long time period.

Application of unit graph

After a unit graph has been constructed for a particular area it may be used to compute a hydrograph of runoff for this area for any individual storm or sequence of storms of any duration or intensity over any period of time. The principle to use in applying the unit graph is to follow the summation process of nature. For example, consider a case where the unit graph is known and data are at hand for the rainfall for two consecutive days. Estimate the percentages of runoff for each of these days. This will give a hydrograph for each of these days of rain. Call them graphs *A* and *B*. The runoff on the first day equals the runoff of the first day of graph *A*. The runoff on the second day equals the runoff on the second day of graph *A* plus the runoff of the first day of graph *B*. The runoff on the third day equals the runoff on the third day of graph *A* plus the runoff of the second day of graph *B*. If the unit graph has a total period of T_o days, the total flood period for this two-day storm will be $T_o + 1$ days. For a six-day storm it will be $T_o + 5$, etc.

The foregoing process of development of a graph for a continuous rainfall at a uniform rate is illustrated in Fig. 1. The triangle *OPQ* with base $T_o = 6$ is the graph of runoff due to a rain during a unit of time—say one day. That rain produces runoff for six days. The average rate of runoff for each day is represented by the ordinates *a*, *b*, *c*, *d*, *e* and *f* in the triangle *OPQ*. The same amount of runoff due to a rain on the second day produces the graph indicated by the first dotted line above *OPQ*. A continued rain with the same daily depth of runoff produces successively the additional dotted graphs. At the end of the fifth day of such continuous rain, with uniform depths of runoff for each day, the runoff graph *ORS* will be formed. The peak at *R* will be the maximum rate of runoff. Further

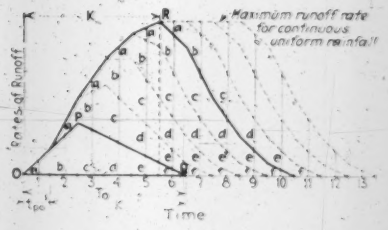


Fig. 1—Simple hydrograph of runoff from a continuous uniform rain, when the unit graph is triangular.

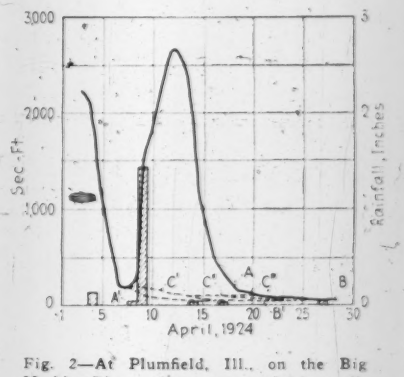


Fig. 2—At Plumfield, Ill., on the Big Muddy River, there was a fairly well-isolated rain of 1.42 in. on April 9, 1924, yielding a hydrograph with ordinates proportional to those of the unit graph.

similar rainfall will result in a continuation of this maximum runoff rate up to the duration of this storm.

Let T_o = Base of a runoff graph for a rain of duration t_{po}. This can be derived from an observed hydrograph.

t_{po} = Unit time of precipitation (one day or one hour).

t_p = Duration of any rainfall.

K = Concentration period.

$K = T_o - t_{po}$.

Let T = Total flood period or base of the graph for any rainfall of duration t_p.

Then $T = K + t_p$.

When $t_p = K$, then $T = 2K$, provided the accumulated depth of runoff (depth of rain — losses) is a constant during each hour of t_p.

When the duration of rainfall, t_p, is less than the concentration period K, then T is always longer than the calculated time of transit from the most

TABLE I — COMPUTATION OF UNIT GRAPH FOR BIG MUDDY RIVER, PLUMFIELD, ILL.

Date, April, 1924	Observed Runoff, Sec.-Ft.	Deduction Base Flow, Sec.-Ft.	Net Runoff, Sec.-Ft.	Unit Graph, Sec.-Ft.	Day
9	1,440	150	1,290	1,950	1
10	1,850	140	1,710	2,590	2
11	2,360	130	2,230	3,370	3
12	2,680	120	2,560	3,870	4
13	2,440	100	2,340	3,540	5
14	1,720	90	1,630	2,470	6
15	940	80	860	1,310	7
16	478	80	398	610	8
17	309	80	229	350	9
18	193	90	103	160	10
19	140	90	50	80	11
20	106	106	0	.....	..d
Total, sec.-ft.-days			13,400	20,300	
Total, inch-miles			500	753	

remote point of the drainage area, generally by 50 to 100 per cent. This fact is due to pondage by the innumerable little detention reservoirs that cover the surface as well as to the effect of channel constrictions in the main stream. In some flat drainage areas with a great deal of pondage the concentration period may be much longer than the possible duration of storms of high intensity. Pondage holds back part of the rainfall until the accumulated depth balances the net rainfall rate and releases it after the rain stops. The inflow and outflow from these detention reservoirs at the end of the concentration period are equal, and there is no further pondage available. Surface pondage must not be confused with surface pocket storage due to sink holes. The latter collect rainfall at the beginning of the storm but do not release it as surface runoff.

Hydrograph for varying rates of rainfall

The ordinates of all graphs of runoff for unit time, t_{po}, are directly proportional to the net depths s of rainall in that same unit time.

This follows because the bases of the graphs T_o are equal. The area of a graph$_1$ equals Σ ordinates$_1$ $\times$ t_{po}, and the area of a graph$_2$ equals Σ ordinates$_2$ $\times$ t_{po}. Also, the area of graph$_1$, as it is a measure of the entire volume of runoff, equals the drainage area $\times$ s_1 and the area of graph$_2$ equals the drainage area $\times$ s_2.

$$\text{Then } \Sigma \text{ ordinates}_1 \times t_{po} = D.A. \times s_1$$
$$\Sigma \text{ ordinates}_2 \times t_{po} = D.A. \times s_2$$
$$\text{or } \frac{\text{ordinates}_1}{\text{ordinates}_2} = \frac{s_1}{s_2}$$

If the ordinates considered are those for a unit graph, $s_2 = 1$ in., and we have the following rule:

The ordinates for any graph of runoff for a unit time t_{po} are equal to the corresponding ordinates of the unit graph multiplied by the given net depth of rainfall. Conversely, the ordinates of a unit graph are each equal to the corresponding ordinates of a given graph (for unit time) divided by the given net depth of rainfall.

In Fig. 1, s was constant day after day. If s varied from day to day, we would have on successive days s_1, s_2, s_3, etc., and the ordinates on successive days would be a_1, b_1, c_1; a_2, b_2, c_2; a_3, b_3, c_3; etc.

A resultant graph would be formed in the same way as the one in Fig. 1, but it would not be a smooth curve. It would reflect all the variations of rainfall.

Instead of the graphical construction, as in Fig. 1, a tabulation of successive ordinate figures can be used to give the values for the resulting hydrograph. This method of computing a hydrograph for any period or sequence of rainfalls from a single unit graph will be illustrated later by examples of specific cases.

Base flow

Base flow, on a hydrograph covering an extended period of time, is indicated by the flow line that continues during a dry period long after the total flood period of the preceding rain has ceased. The point where the total flood period due to surface runoff ceases and only groundwater or base flow continues is not capable of exact determination. However, it can be closely approximated by inspection of surface-runoff hydrographs terminating a dry period. The base flow exists and is a part of almost any observed hydrograph of runoff. In evolving a unit graph by the procedure heretofore mentioned it is necessary first to subtract the base flow from the observed hydrograph in order to arrive at the net hydrograph due solely to the rainfall. The base flow can be estimated by consulting the available flow records made during dry periods and selecting a base-flow line that followed a rainfall period similar to the period preceding the graph in question. It is preferable that the unit graph should be derived from a graph due to a rain of high intensity. The base flow then is a small percentage of the surface runoff, and any error due to estimated base flow is slight.

Unit graph constructed for the Big Muddy River

The drainage area of the Big Muddy River at Plumfield, Ill., is 753 square miles. Daily rainfall records of the U. S. Weather Bureau are available at Mount Vernon, in the center of the upper portion, and at Benton, near the center of the lower portion of the drainage area. The records of the Mount Vernon station apply to 43 per cent of the area, and the Benton records apply to 57 per cent. The average daily flow of the Big Muddy at Plumfield is contained in the water-supply papers of the U. S. Geological Survey.

The derivation of a unit graph is obtained preferably from an observed hydrograph due to a single isolated 24-hour rainfall of high intensity, without any material rainfall either during the runoff period or just preceding it.

A search of the records shows a fair example of such a rainfall on April 9, 1924. The record of daily precipitation at this time was as follows:

Date — April, 1924	4	8	9	14	16	17	22
Mt. Vernon, in.....	0.16	....	0.94	0.08	....	0.04	0.05
Benton, in...	0.09	0.05	1.80	....	0.01	0.02	0.08
Weighted average, in...	0.12	0.03	1.42	0.03	....	0.03	0.06

Fig. 2 shows the runoff during this period and the average daily rainfalls. In Table I, column 3 lists the runoff due to rains prior and subsequent to the rain of April 9, which must be deducted from the daily runoff figures to give the desired net runoff due solely to the rain of April 9.

The values to be deducted are derived in the following manner: In Fig. 2, starting at the low stage of April 7, draw the line A' B' with daily ordinates of flow equal to those on the line A B. A' B' then represents the runoff and base flow as it tapers off from stage A' or A, provided no subsequent rain occurs. There were, however, three small rains of 0.03 in. each, on April 8, 14 and 17. The runoff from these small rains was appreciable in this month, as shown by the runoff record of 193 sec.-ft. on April 7 and 226 sec.-ft. on April 8. This increase of 33 sec.-ft. was due to the 0.03-in. rain on April 8. By reference to the main graph (Fig. 2) it is found that for this drainage area the peak comes on the fourth day, and runoff ceases about the tenth day after the end of the rain. The net peak flow in Fig. 2 is about 2,500 sec.-ft. for a rain of 1.42 in. By proportion the peak flow for a rain of 0.03 in. would be 53 sec.-ft. The smaller rain, however, has a smaller runoff. Call it a peak of 40 sec.-ft. The runoff of the 0.03-in. rain then may be represented by a triangular graph with base of ten days and height of 40 sec.-ft. on the fourth day. Now add successively, in Fig. 2, three such small graphs to the ordinates of the line A' B' with their peaks as shown at C', C'' and C'''. The ordinates to the line A' C' C'' C''' now represent the deductions, and numerically they form column 3 of Table I. Column 2 minus column 3 gives the net runoff due solely to the rain of April 9.

The next step is to determine the figures for a unit graph for this drainage area. It will have the same time base as the graph represented by column 4. The ordinates, however, will be in proportion to the ordinates of column 4 as 1 in. is to the runoff depth due to the rain of 1.42 in. This runoff depth is found as follows: The sum of the average daily runoffs in column 4 is 13,400 sec.-ft.-days. This total volume of runoff equals 500 inch-miles. The total volume of rainfall was 1.42 in. $\times$ 753 square miles of drainage area, or 1,070 inch-miles. Hence:

$$\text{Percentage of runoff} = \frac{500}{1{,}070} = 46.8$$

per cent.

Depth of runoff = 1.42 in. × 46.8 per cent = 0.66 in.

Column 5 of Table I, which is obtained by dividing the values in column 4 by 0.66, gives the figure for the unit graph. Note that the total, expressed in inch-miles, equals the drainage area at Plumfield. This affords a partial check on the computations.

Computing the hydrograph

We can now apply this unit graph, which was derived from data for April 9, 1924, to the determination of runoff from rainfall in the months of April and May, 1927. In Table II, columns 1 and 2 give the dates and the weighted-average depth of rainfall over the drainage area. Column 3 is the estimated percentage of this rainfall, which appears as runoff, determined according to the rule to be stated in a subsequent paragraph. Column 4 is the product of columns 2 and 3, giving the depths of runoff. Column 5 is the unit graph for Plumfield as heretofore computed. In column 6 are listed the figures for graphs of runoff due to each day of rainfall, obtained by multiplying the figures in column 5 by a figure in column 4. The beginning and end of runoff are entered opposite their respective dates for each rainfall. Column 7 is the summation of runoffs on any day due to any and all rainfalls that had any effect on that day.

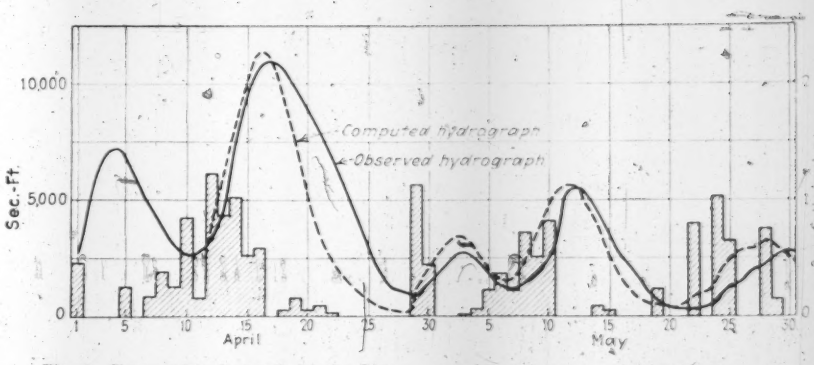


Fig. 3—Computed hydrograph for the Big Muddy River at Plumfield, Ill., for April and May, 1927, agrees closely with the observed rates of runoff.

The dotted line of Fig. 3 is the computed hydrograph of runoff plotted from column 7 of Table II. The heavy line is the observed graph plotted from the U.S.G.S. record of flow for comparison. Base flow was ignored in this example.

TABLE II — COMPUTED RUNOFF FOR BIG MUDDY RIVER AT PLUMFIELD, ILL., APRIL AND MAY, 1927

	Day of Rainfall	Date, 1927	Rainfall, In.	Per Cent Runoff	Runoff, In.	Unit Graph Runoff, Sec.-Ft.	Runoff Due to Rain on Day Noted										Total Runoff, Sec.-Ft.	Date, 1927
							1											
April	*1*	1	0.45	15	0.068	1,950	132											1
		2				2,590	176											2
		3				3,370	229											3
		4				3,870	263	*2*										4
	2	5	0.25	15	0.037	3,540	240	72										5
		6				2,470	168	96	*3*									6
	3	7	0.16	17	0.027	1,310	89	125	53	*4*								7
	4	8	0.38	27	0.102	610	41	143	70	199	*5*							8
	5	9	0.25	32	0.080	350	24	131	91	264	156	*6*						9
	6	10	0.85	52	0.440	160	11	91	104	344	207	858	*7*					10
	7	11	0.15	55	0.083	80	5	48	96	395	270	1,140	162	*8*			2,416	11
	8	12	1.22	72	0.880			23	67	361	309	1,481	245	1,715	*9*		4,201	12
	9	13	0.87	79	0.690			13	35	252	383	1,700	280	2,280	1,345	*10*	6,188	13
	10	14	1.01	81	0.820			6	16	134	198	1,556	321	2,964	1,785	1,600	*11*	8,580	14
	11	15	0.51	83	0.423			3	9	62	105	1,086	294	3,403	2,322	2,120	825	*12*	10,229	15
	12	16	0.58	86	0.500				4	36	49	577	205	3,114	2,666	2,760	1,095	975	11,481	16
		17					*13*		2	16	28	268	109	2,172	2,440	3,170	1,424	1,295	10,924	17
	13	18	0.05	80	0.040		78	*14*		8	13	154	51	1,152	1,702	2,900	1,635	1,682	9,375	18
	14	19	0.16	81	0.130		105	254	*15*		6	70	29	537	905	2,022	1,497	1,932	7,355	19
	15	20	0.04	81	0.033		135	337	64	*16*		35	13	308	420	1,073	1,044	1,767	5,196	20
	16	21	0.09	82	0.074		155	438	86	14	*17*		7	141	242	500	554	1,233	3,500	21
	17	22	0.03	82	0.025		142	503	111	192	49			70	110	287	258	655	2,377	22
		23					99	460	128	249	65				55	131	148	305	1,640	23
		24					52	321	117	286	84					66	68	175	1,169	24
		25					24	170	82	262	98						34	80	750	25
		26					14	79	43	183	89							40	448	26
		27					6	45	20	97	62								230	27
		28					3	21	12	45	33	*18*							114	28
	18	29	1.13	58	0.655			10	5	26	15	1,277	*19*						1,333	29
	19	30	0.44	65	0.286				3	12	9	1,694	558						2,276	30
		1								6	4	2,204	704						2,954	1
		2									2	2,535	963	*20*					3,500	2
	20	3	0.01	38	0.004							2,318	1,106	8	*21*				3,432	3
	21	4	0.06	40	0.024							1,618	1,011	10	47	*22*			2,686	4
	22	5	0.22	45	0.099							858	706	14	62	193	*23*		1,833	5
	23	6	0.38	53	0.200							399	374	16	81	246	390	*24*	1,506	6
	24	7	0.22	54	0.119		*25*					229	174	14	93	334	518	232	1,594	7
	25	8	0.72	65	0.468		913	*26*				105	100	10	85	383	674	308	2,578	8
	26	9	0.51	70	0.357		1,210	697	*27*			52	46	5	59	350	774	401	3,594	9
	27	10	0.82	72	0.590		1,575	925	1,150				23	2	31	245	708	460	5,119	10
		11					1,810	1,202	1,526					1	15	130	494	421	5,599	11
		12					1,654	1,381	1,986					1	8	60	262	294	5,646	12
		13					1,154	1,262	2,281	*28*				0	4	35	122	156	5,014	13
	28	14	0.09	55	0.050		613	882	2,087	98	*29*				2	16	70	72	3,840	14
	29	15	0.04	56	0.022		285	468	1,456	130	43					8	32	42	2,464	15
		16					164	218	773	168	57						16	19	1,415	16
		17					75	125	360	193	74							10	837	17
		18					37	57	206	177	85	*30*							562	18
May	*30*	19	0.23	50	0.115			29	94	123	78	224							548	19
		20							47	66	54	298							465	20
		21								31	29	388	*31*						448	21
	31	22	0.80	30	0.240					18	13	445	468						944	22
		23								8	8	407	622	*32*					1,045	23
	32	24	1.03	35	0.361					4	4	274	809	705	*33*				1,796	24
	33	25	0.65	40	0.260						2	151	929	935	507				2,524	25
		26										70	850	1,216	673				2,809	26
		27					*34*					40	593	1,397	876				2,906	27
	34	28	0.75	45	0.338		660	*35*				18	314	1,278	1,005				3,275	28
	35	29	0.14	45	0.063		975	123				9	146	892	920				2,965	29
		30					1,139	163					84	473	643				2,502	30
		31					1,308	214					38	220	340				2,120	31

The vertical columns headed by numbers in *italics* are made up by multiplying the runoff for the day corresponding to that number by the successive daily values of the unit-graph ordinates. They represent the daily values of runoff due to the rain on the day in question. The total value of runoff for each day is obtained by adding these partial values horizontally.

Fig. 4 shows the computed hydrograph of flow of the Delaware River at Port Jervis, N. Y., for August, 1928. This is an example of runoff from topography with relatively steep slopes. The drainage area is 3,070 square miles. The unit graph for Port Jervis (Fig. 6) was derived in a manner similar to that presented in detail for the Big Muddy River, based on a 2.58-in. rainfall on Nov. 16, 1926.

The observed runoff, according to the U.S.G.S. record, was 85 per cent of the rainfall during that storm. As a check on the unit graph thus derived, another graph was computed from the average

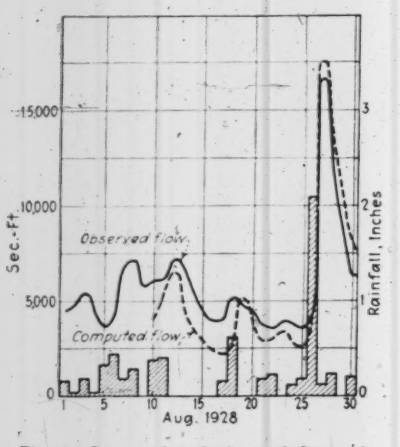


Fig. 4—Computed and observed flows of the Delaware River at Port Jervis, N. Y., reflect the quick runoff due to the steep slopes of the watershed.

rainfall of 1.79 in. on Oct. 6, 1926, when the recorded runoff was only 23.8 per cent of the rainfall. This unit graph gave a 24-hour peak rate of 23,900 sec.-ft., compared with 24,900 sec.-ft. of the former unit graph. Similar comparisons on other drainage basins indicate that this degree of accuracy may be obtained by the method, regardless of the amount of rain in a unit of time or the percentage of runoff.

Fig. 5 is a hydrograph of the observed flow on the Sangamon River at Oakford, Ill., during March, April and May, 1927, together with the hydrograph computed from an observed unit graph due to rain on March 14, 1922.

In Fig. 6 unit graphs for a number of drainage basins are shown. They reflect the effects of shape, size, topography and pondage of different basins, each with a 24-hour rainfall producing a 1-in. depth of runoff. When no streamflow records from a particular area are available, it is possible to derive a unit graph by analogy from unit graphs from similar basins with like topographical characteristics.

The ordinates and time intervals of the unit graphs for two similar watersheds of different sizes are proportional to the square root of the watershed areas, provided the difference in size is

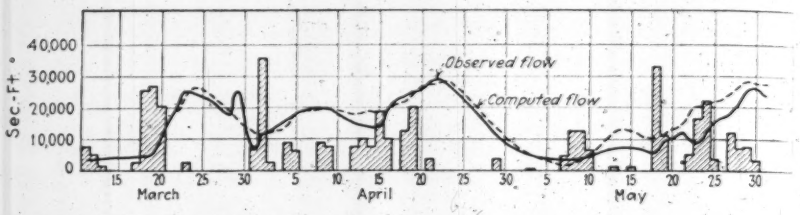


Fig. 5—Close agreement between the computed and observed hydrographs for the Sangamon River at Oakford, Ill., for a three-month period in 1927. Computed flow was based on data recorded in 1922.

not great. When the difference in areas is large, a correction factor must be applied. Referring to Fig. 6, all of these unit graphs can be reduced by analogy to unit graphs for any similar basins—say for a similar area of 1,500 square miles in each case. The peak rates of flow for two of these cases would then be as follows:

	Area, Sq. Miles	Peak Runoff, Sec.-Ft.	For Similar Area of 1,500 Sq. Miles, Sec.-Ft.
Port Jervis	3,070	25,100	17,100
Taylorville	510	4,900	6,500

This suggests the possibility of developing a series of unit graphs covering an extreme range of drainage-basin characteristics and sizes. Such a series of unit graphs would in effect constitute a range of runoff-rate coefficients to be used in connection with given rainfalls and the seasonal percentage of rainfall runoff.

Percentage of runoff

Runoff is not primarily a percentage of rainfall. As Robert E. Horton has pointed out, it is the residual amount after deducting losses—interception, pocket storage, evaporation and infiltration—from rainfall. The writer has, however, followed the customary method, used in discussions of runoff from sewered areas, of expressing runoff as a percentage of the rainfall. Confining ourselves to surface runoff as compared with groundwater outflow seepage, or base flow, we find that the percentage of runoff increases with the rate and duration of precipitation. The percentage is also increased by the occurrence of previous precipitations. It varies with the season according to the temperature and amount of vegetation, the topography, soil and conditions causing pocket storage and pondage.

Percentages of runoff, considered only in relation to a single one of the foregoing factors, appear very erratic. If, however, the observations are confined to a single area or to closely similar areas and if they are segregated according to the seasons, the data will be quite consistent. If, in addition, cognizance is taken of the effect of prior precipitation, then the percentages of runoff will be in harmonious accord.

The figures for percentage of runoff

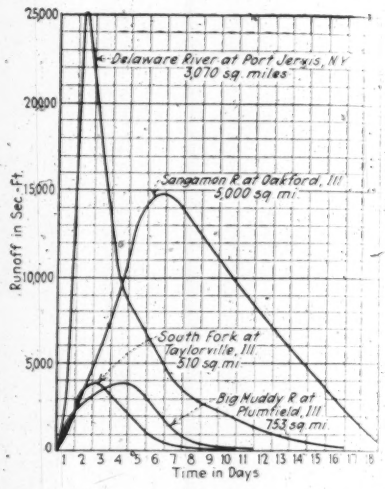

25,000
20,000
15,000
10,000
5,000
0
Runoff in Sec.-Ft.
Delaware River at Port Jervis, N.Y. 3,070 sq. miles
Sangamon R at Oakford, Ill. 5,000 sq. mi.
South Fork at Taylorville, Ill. 510 sq. mi.
Big Muddy R at Plumfield, Ill. 753 sq. mi.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Time in Days

Fig. 6—Unit graphs for different watersheds reflect the variations in shape, size, topography and pondage.

used here in computing the unit graph were obtained for a given drainage area and a rainfall of known amount. With several such figures applying to the same calendar month, a curve was drawn showing runoff per cent plotted against rainfall intensity. Fig. 7 shows a series of such curves for various watersheds. Each curve is applicable to a certain month only. In preparing the diagram the effect of previous rainfall was taken into account by adding a certain proportion of it to that of the day in question, according to the factors given in Table III.

TABLE III — PROPORTION OF PREVIOUS RAINFALL TO BE ADDED IN DETERMINING PER CENT RUNOFF

Number of Intervening Dry Days	Proportion of Previous Rainfall to Be Added to Given Day
0	1.00
1	0.8
2	0.6
3	0.5
4	0.4
5	0.3
6	0.2
7	0.2
8	0.1
9	0.1
10	1/11
11	1/12

For example: Given a record of average daily rainfalls in April on the Big Muddy drainage basin as follows: April 28, 2 in.; 26, 1 in.; 24, 0.5 in.; and 10, 1 in. Required the runoff on April 28: by rule in Table III we have 2 in. +

1 in. × 0.8 + 0.5 in. × 0.6 + 1 in. × $\frac{1}{10}$ = 3.16 in. Referring to diagram Fig. 7, we find that the ordinate for 3.16 in. on the Big Muddy in April is 70 per cent. The runoff from the rain of April 28 is therefore 2 in. × 70 per cent = 1.4 in. It will be noted that the effect of rains two or three weeks prior to the rain in question have slight effect on the percentage of runoff.

The principle of the foregoing is rational, but the rule is empirical and only roughly approximate. In Table II use has been made of the foregoing in deriving the column headed "Per Cent of Runoff," in the absence of more exact data. It agrees fairly well with the facts in most cases. To use Fig. 7, first find the summation of rainfall by the above rule. The ordinate in Fig. 7 corresponding to this summation of rainfalls gives the per cent runoff, and this should be applied to the rainfall of the given day.

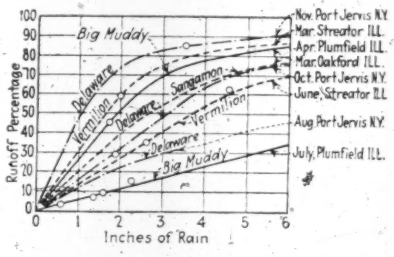


Fig. 7—For any calendar month the percentage of rainfall appearing as runoff varies consistently with the quantity of precipitation.

Accuracy of the method

The accuracy of computed runoff is limited by the accuracy of the estimated percentage of runoff, as heretofore explained. The observed hydrograph reflects all the numerous factors influencing runoff from rainfall on a given area. The unit graph should be based upon a uniform depth of rainfall over the entire area. The unit graph for the Big Muddy River was based on a rain of 1.80 in. at the lower end and 0.94 in. at the upper end. This unit graph therefore has excessive rates of runoff for the rising stage and insufficient rates for the falling stage. This is reflected in the computed curve in Fig. 3. After a trial application like this it is possible to adjust the unit graph, and with the rectified graph to compute the runoff as in Table II, obtaining somewhat closer agreement with the observed runoffs.

The published records of rainfall by the U. S. Weather Bureau are for total precipitation in a calendar day of 24 hours. The published data of runoff by the U.S.G.S. are likewise average-flow records for this 24-hour period. This leads to the use of a 24-hour time unit as the basis for the unit graph. In general this suffices. There are, however, relatively small drainage areas with steep slopes and high velocity of flow where the 24-hour unit will not suffice and a shorter time unit is necessary. The writer has found this to be true in the case of upper tributaries of the Delaware River like the West Branch at Hales Eddy and the East Branch at Fish Eddy, N. Y. The effect of storage by water-power dams will modify the observed flow as contrasted with the computed flow. This effect is very apparent at Hales Eddy, and to a lesser degree affects the comparison of observed and computed flow at Port Jervis, N. Y., as shown in Fig. 4.

The unit-graph method in runoff problems offers a number of improvements over existing procedures. Present applications of the rational method are confined to small areas and to assumed rainfalls during the entire period of concentration. In the unit-graph method the runoff from any sequence of rainfalls may be analyzed. The relative effects of long-continued rains of low intensity and short storms of high intensity may be compared. The important effect of surface and channel pondage for storms of less than the concentration period is automatically included by the application of a unit-graph derived from an observed hydrograph. Runoff rates from hypothetical storms can be computed in exactly the same manner as was illustrated for actual rainfalls in Table II.

The unit-graph method enables a runoff record to be computed when only limited streamflow data are available. This application is of special service in investigations of drainage, flood control, water power and water supply.

Systematic Maintenance Essential for Fire Hydrants and Valves

BECAUSE of the relative infrequency with which they are operated, regular inspection of the valves and hydrants of a waterworks system is essential if they are to be maintained in good working order at all times. Well-formulated rules for the guidance of the maintenance staff were laid down by W. H. Durbin, superintendent of the Terre Haute Water Works Corp., at the meeting of the Indiana Section of the American Water Works Association at Lafayette on March 9, 1932.

All valves should open in the same direction, and if necessary, new stems and nuts should be installed so as to bring about a condition of uniformity. The usual result of having the two types of valve in the system is unsatisfactory service, twisted stems and higher maintenance costs. The necessity of uniformity cannot be too strongly emphasized, said Mr. Durbin.

Maintaining valves in Terre Haute

It is the practice in Terre Haute to inspect each valve once a year. A permanent record card has entered upon it the date of inspection, the condition of the valve and valve box, the name of the inspector and other information of a pertinent nature. The usual inspection consists of placing the valve key upon the nut and turning it several times to determine if it operates freely, also to make certain that the valve is fully open. If the valve does not work freely and forcing appears inadvisable to the inspector, that fact is noted on the card so that the valve can be given proper attention later. The operation of a valve is often made more difficult by the drying out of the packing. Where this is the case considerable relief can be obtained by removing the stuffing-box gland, loosening up the packing and lubricating it. All valve boxes that are found to be covered are adjusted to the grade of the street.

At one time it was the practice at Terre Haute to build brick wells or vaults for every valve located in a paved street irrespective of its size. Experience has demonstrated that the cost of maintaining the wells and especially the iron cover is far in excess of any expense incurred in the valves themselves. It is very seldom necessary to repack a valve, and where this is needed it is usually more economical to dig up the street than to maintain the well. Should the stem become broken or bent, even with the ordinary well, it has often been impossible to make the needed repairs without removing the cover and possibly some of the brickwork. Under heavy automobile traffic it is almost necessary to use a malleable lid to prevent breakage, and this adds to the cost still further. For a gear-operated valve the vault is thought to be advisable, but not for a straight operating valve 16 in. or less in diameter.

Inspecting and lubricating hydrants

Fire hydrants serve a highly important purpose in the distribution system, and it is absolutely necessary that they be always in first-class working order. At Terre Haute two general hydrant inspections are made each year. At these times the hydrant is opened and closed, packed if necessary, the revolving nut is lubricated, nozzles are properly leaded and drains are opened. In addition to these two general inspections, frequent visits are made during the winter months. Where the groundwater plane is above

the level of the hydrant drain, the drain is closed and the hydrant is pumped out. Each hydrant is inspected after its use by the fire department. This is especially important in winter.

Several different lubricants have been tried upon the revolving nut of fire hydrants. The most satisfactory results have been obtained by using the heavier grade of transmission oil. Plumbago mixed with the lighter grade of oil did not prove satisfactory, as the oil either evaporated or ran off in the summer and left the dry graphite, which offered practically no lubrication in the winter. Glycerine was used for a time, but it furnished lubrication for only four or five months. Glycerine does not have sufficient body to furnish proper lubrication under the severe weather conditions that a hydrant experiences. The heavy transmission oil lasts, under ordinary circumstances, about two years.

The use of chains on the hydrant caps is not favored by Mr. Durbin, as they usually rust and become very difficult to remove when necessary.

Contractors are not permitted to use hydrants for construction purposes. Where water is desired a tap is usually made in the hydrant branch and a temporary meter is installed.

Where sewers are to be flushed or inlets cleaned, the street department notifies the waterworks, and a controlling valve is placed upon the hydrant. As soon as the work has been completed the hydrant is shut off by waterworks men and the valve is removed. The street foremen are not permitted to open and close the hydrants.

Repair parts of every make and style of hydrant in use are kept in stock. In the event a hydrant is broken it is the practice to remove the old barrel and install another its its place. Repairs to the broken part are made at a later date. In this way the city is without fire protection for only a minimum of time. Every hydrant should be installed with an independent valve on the hydrant branch, so that repairs can be made without shutting off the mains in the street.

Light Floor Combines Gypsum Blocks and Concrete Slab

By Henry J. Schweim
Chief Engineer, Gypsum Association, Chicago, Ill.

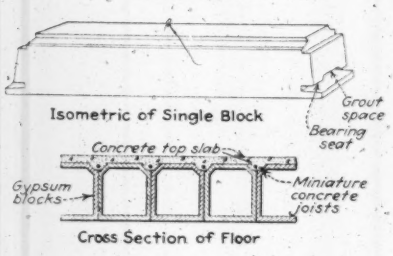
THE COMPLETION in Chicago of a four-story addition to the present eight-story Maurice L. Rothschild Building marked the introduction of a new type of floor employing a combination of precast gypsum units and poured-in-place concrete known as the "unitrave system."

This floor, developed by the Avery Brundage Co., contractor on this job in collaboration with S. J. Branson, the inventor, consists essentially of special hollow precast gypsum blocks that span between the floor beams and act as a permanent form for the concrete slab. It provides a flat uniform ceiling and eliminates all centering and shoring. The blocks are cast with beveled edges so as to provide for a miniature concrete joist every 12 in., as shown in Fig. 1. The concrete slab, with standard reinforcement, is designed to carry the entire live load.

The length of the gypsum block is determined by the spacing of the floor beams. In the Rothschild Building the spans were mostly 6 ft. The size of the floor beams likewise determines the depth of the block. In placing, the block is held by two men, one at each end with a strap passed around the block. One end of the block is let down far enough to clear the lower flange of the I-beam and is then moved longitudinally so as to permit the other end to clear the other supporting beam. The second end is then let down until the shoe, at the end of the block, can be passed under the lower flange of the beam. The first end is then raised to a horizontal position and the block moved longitudinally until it engages the bottom flange of both beams. The block is supported on the flange of the I-beam at the four bearing seats indicated in the isometric view. The lower flanges of the block in adjacent panels meet under the supporting beams, thus insuring alignment and holding the blocks in position until the concrete is poured.

This special gypsum block weighs from 15 to 18 lb. per linear foot, depending on the depth of the floor beams, and it will span up to 6½ ft. Although not designed to carry other than construction loads, a standard block on a 6-ft. span has been loaded to 400 lb. per sq.ft. without failure.

Fig. 1—Details of lightweight floor in which gypsum blocks serve as formwork for thin concrete slab, providing a flat ceiling upon which plaster may be directly applied.



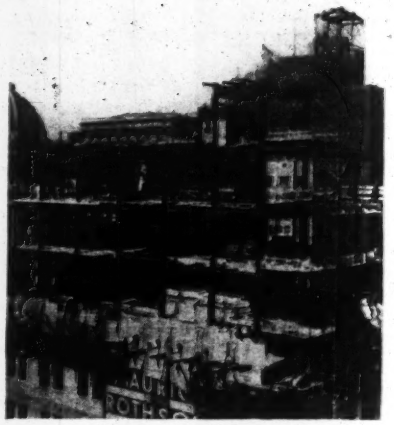


Fig. 2—Adding four stories to Chicago building in which gypsum-block floors, in addition to assuring light weight, furnished a platform for the workers and eliminated concrete forms and shoring.

Among the advantages of this type of floor are that the lower surface of the blocks form a level ceiling; that no falsework and shoring of any kind is required; that the upper surface of the blocks provides a working deck on which all trades may proceed immediately with their work without delay or interference; and that the blocks serve as the form on which the reinforced-concrete top slab is poured, the concrete slab passing over and engaging the top flanges of the steel beams. The blocks provide a definite bracing against lateral distortion and wind stresses. The plaster is applied directly to the gypsum block, no hangers, runners or lath being required. An especially advantageous factor in winter work is that the blocks can be installed and the building housed in with the exterior walls before the concrete slabs are poured. This is significant, considering the cost of heating materials and protecting the concrete slabs.

Ventilation Equipment Adds to Cost of Mersey Tunnel

The new Mersey tunnel, now nearing completion under the River Mersey in England, is expected to cost £6,500,000 ($31,500,000 at par) instead of £5,000,000 as originally planned, because of the need for a more elaborate ventilation system than that originally figured. The ventilation system to be adopted provides for the air to be blown through a bottom duct and exhausted from the whole of the area above the road at a rate of 2½ million cu.ft. per minute. The proportion of carbon monoxide in the air will not rise above four parts in 10,000 during the short periods of peak traffic.

Bridging Genesee Gorge With Concrete Arches

Ridge Road or Veterans' Memorial Bridge in Rochester, N. Y., built in the Roman tradition, with semicircular arches and granite facing, includes a main arch of 300-ft. span and 150-ft. rise with each arch rib on a separate foundation

By Frank P. McKibben and Richard de Charms

Consulting Engineer and Resident Engineer, Respectively

AMONG the several large concrete-arch bridges built in 1931, such as the George Westinghouse at Pittsburgh, Rogue River in Oregon, Wissahickon Creek in Philadelphia, and Ridge Road in Rochester, the latter stands out as a particularly monumental structure by virtue of its complete facing with granite and its buttressed main piers rising 175 ft. above the water. Situated at a point where a bridge has not previously existed, the new structure forms a much-needed link between two sections of the city that are separated by the deep gorge of the Genesee River. It is a notable fact that all the above-mentioned bridges are on new roads or new alignments, each furnishing in its special way the increased highway efficiency that modern requirements demand. —EDITOR.

THE NEW Ridge Road bridge that connects two sections of the city of Rochester, N. Y., across the deep gorge of the Genesee River is one of the largest reinforced-concrete structures completed during the past year. The main arch, with its span of 300 ft., carries a 60-ft. roadway 171 ft. above the river. Faced with granite, the seven semi-circular arches in the structure present the appearance of an ancient Roman bridge, as was planned by characteristic Roman treatment of the ring stones, arrangement of the masonry in the spandrel walls and the use of large buttresses at the main river piers. Structurally, the bridge is noteworthy in several particulars, among which are separate foundations for each of the four ribs, a cantilever portion of each outside rib foundation that carries a triangular buttress at either end of each abutment, and special expansion joints at intervals of about 50 ft. that divide the bridge superstructure into entirely separate units. Construction work on the bridge was also somewhat unusual and spectacular.

The Genesee River, about 100 miles east of the Niagara River which descends from the level of Lake Erie to that of Lake Ontario in one tremendous fall, descends almost an equal amount from its upper reaches to Lake Ontario in three falls (all within the city of Rochester), and then proceeds leisurely to Lake Ontario through a beautiful gorge that restricts traffic movement between the two separated sections of the city. The gorge offers a great opportunity to the bridge designer, but it also imposes the obligation that his creation must enhance rather than destroy the natural beauty. The new Ridge Road bridge typifies an effort to facilitate man's activities while leaving undefiled a great heritage.

Including the new structure, five bridges have been built across the Genesee north of Lower Falls. Of these, three are now in existence. The first to span the gorge, the Carthage bridge (1819), consisted of a braced arch of 352-ft. span with its summit 196 ft. above the water, carried by nine wooden ribs each 2 ft. 4 in. thick. This structure collapsed under its own weight some fifteen months after completion. The second bridge, of the suspension type, with a main span of 380 ft. and a maximum height above water of 208 ft., remained standing only nine months and collapsed on April 21, 1857, under the weight of snow that had collected upon it. Driving Park Avenue bridge, a three-hinged spandrel-braced wrought-iron arch, designed by L. L. Buck and built in 1890, still is in good condition after 40 years of service. The fourth structure, Stutson St. bridge, near Lake Ontario, is of more recent construction.

Fig. 1—Ridge Road bridge in Rochester, N. Y., spans gorge of Genesee River in a series of semicircular arches, the largest of which is 300 ft. Granite facing was used as outside forms for the concrete in the piers, spandrels and exterior ribs.

Preliminary studies

Before adopting finally the executed design for the Ridge Road bridge, studies embodying engineering and architectural features were made of fifteen proposals. Among the designs in steel were two-hinged arched ribs of plate-girder sections as well as ribs of the truss type. In concrete, ribbed arches with and without spandrel walls were given careful consideration. These types were further varied by investigations in double-deck and in single-deck construction. In studying the number of arches to be used it was found that to fit properly into the site an odd number of arches must be employed. At first it was thought the Pont du Gard type consisting of two or three tiers of arches might be appropriate for the location, but the length of the bridge proved to be too small for its height. After preliminary studies the structures with two decks were abandoned as being undesirable, largely on account of unsatisfactory entrances resulting from the difficulty of bringing the two decks to the same level at either end of the bridge.

The project as built comprises four units: the east approach, the bridge proper, the west approach from the bridge to Maplewood Boulevard, and the West Park Road. The east approach consists largely of a traffic-distributing circle, as shown in Fig. 2. The west approach through Maplewood Park comprises a roadway 500 ft. long and an intersection with Maplewood Boulevard. West Park Road, an existing boulevard, is carried underneath the bridge behind a new retaining wall along the west bank of the river.

Design features

The Ridge Road bridge consists of a 60-ft. roadway and two sidewalks, carried over the gorge on a semi-circular main arch of 300-ft. clear span, flanked by three small arches of 50 or 58 ft. on either bank, making seven arches in all. Structurally, the bridge is composed of a deck on reinforced beams and columns that transfer the loads to four parallel arch ribs, each supported on its own separate foundation. However, to avoid the naked appearance of the open spandrel ribbed construction, walls have been introduced at the piers, at abutments and at

spandrels; and "filler walls" have been placed between the ribs of all of the arches.

The granite masonry facing of the piers and side walls, in courses generally 5 ft. deep, is an integral part of the concrete walls and columns to which the stones are attached. As the alternate courses are of different thicknesses varying from 4 to 10 in., and as each stone is anchored to the concrete with eight galvanized-iron anchor rods, a thoroughly good bond is secured. In constructing the bridge the stones of each horizontal course of masonry were placed in position, with anchors attached; then they were tied back with rods to the inside forms of the spandrel wall. Concrete was then deposited between the granite and the wooden backforms. Although this is a slow and expensive method of facing, it is believed to increase greatly the life, and to enhance considerably the appearance of the bridge.

One of the most interesting structural features is the cantilever, placed on the lower portion of each outside rib of the main 300-ft. span to support the large triangular buttresses, (Figs. 2 and 3). Each buttress is hollow and consists of a concrete wall faced with granite and braced at several levels by horizontal diaphragms or floors, the whole supported on the cantilever projecting from the main rib.

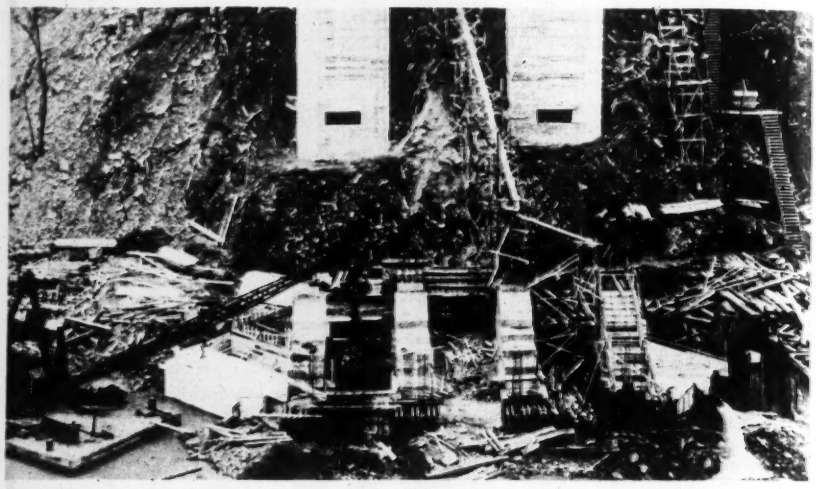
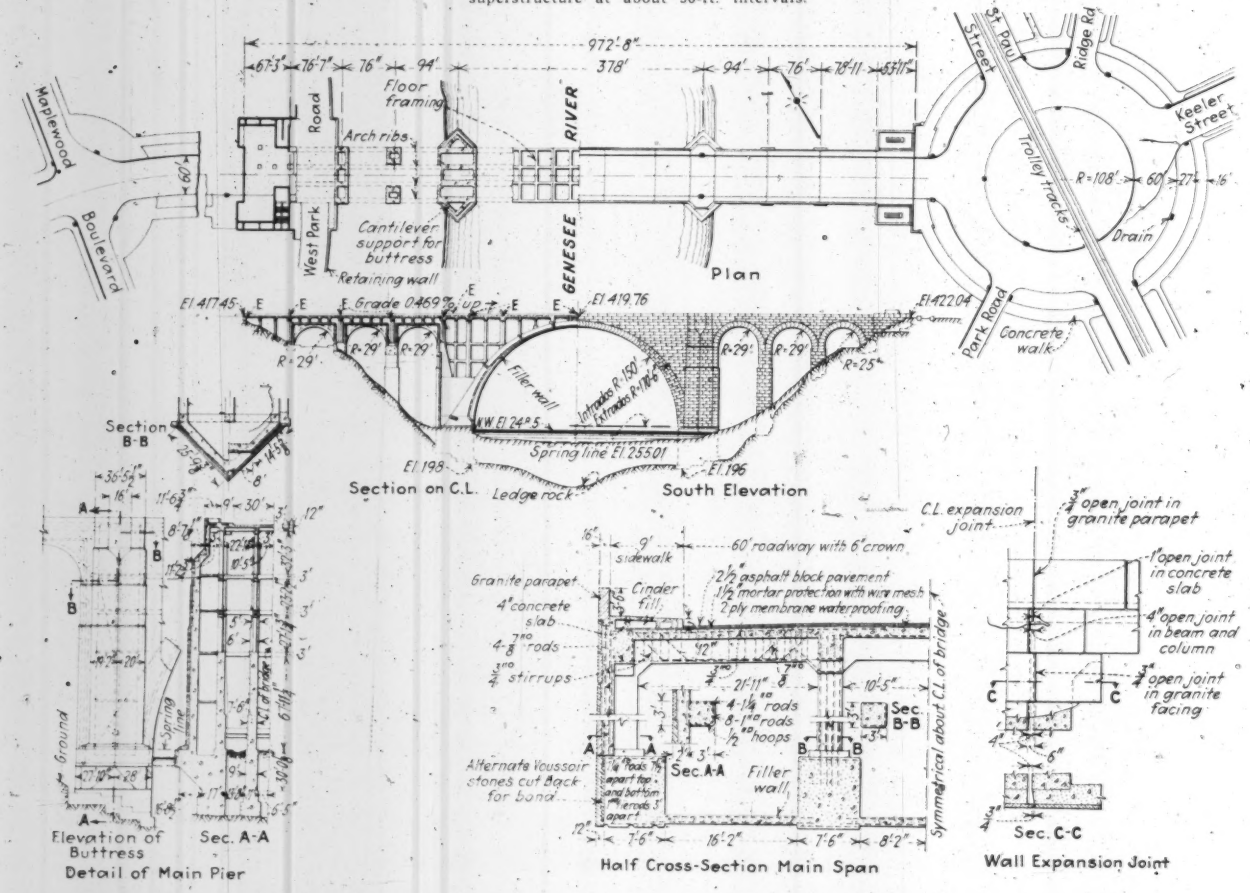


Fig. 3—Constructing separate foundations for four main-arch ribs. Triangular extensions of outer foundations are cantilevers that carry the pier buttresses. Floating plant used for excavation and material handling. Concrete is mixed above on bank and chuted into place.

Ample provision for expansion and contraction was necessary, and joints were placed in sidewalls and in the deck at variable distances, averaging about 50 ft., which completely sever the structure above the rib. To maintain an appearance of continuity in the stone spandrel walls, a stepped or zigzag open joint was left between adjacent stones at each of these ex-

Fig. 2—Structural features of Ridge Road bridge at Rochester, N. Y., include separate foundations for each arch rib, filler walls between the ribs, 175-ft. piers with buttresses carried on a concrete cantilever, and complete articulation of the superstructure at about 50-ft. intervals.



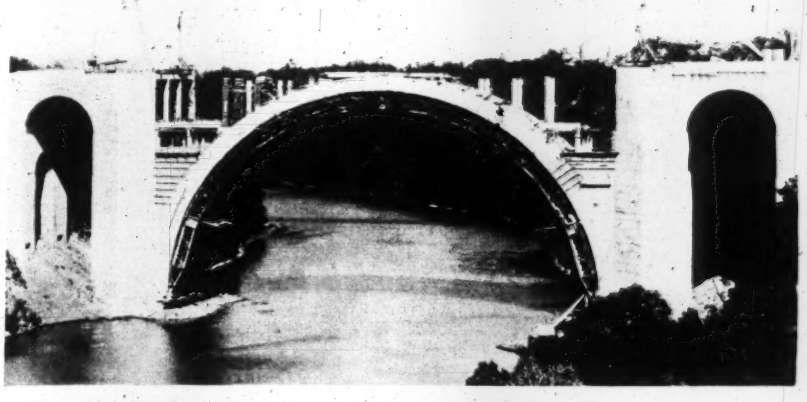


Fig. 4—Main 300-ft. arch was constructed on five-hinge steel centers supporting forms for two ribs at a time. Derricks with booms of 200 and 155 ft. placed centers and handled construction materials. Granite facing was utilized as outside forms.

pansion points, not only vertically at the ends of the stones but horizontally for a short distance as well. Back of each of these zigzag joints the concrete spandrel wall was separated and attached to two independent columns, each carrying its own floor beam. This detail, as well as cross-sections of the deck and main pier, are shown in Fig. 2.

Construction procedure

Foundations — Adequate borings made in advance of design showed the geological formations of the gorge to consist of red and green shales overlying hard red sandstone. The layer of green shale, found in upper levels of the banks, was hard upon removal, but it disintegrated to clay in a short time when exposed. Red sandstone, therefore, was utilized to afford excellent bearing for all deep foundations, while hard red shale supports some of the smaller walls and piers at higher levels. The four separate foundations at each large river pier were built independently in separate steel cofferdams, extending to a maximum depth of 55 ft. below water level. All steel sheetpiling, timber bracing, pumps, excavated material, etc., were handled by floating equipment, as shown in Fig. 3, where also may be seen the concrete chute descending the steep bank from the concrete mixer.

Handling Concrete—Two concrete-mixing plants were used, one at the top of each bank. Steel reinforcing, granite facing and concrete for the end platforms and short shore arches were placed directly by derricks, moved forward toward the river as the end spans progressed. Where necessary, chutes were employed to place concrete. The materials for the main river piers were handled by floating equipment, the concrete being placed by chutes wherever possible. After the main river piers had been carried up to roadway level and the adjoining shore spans constructed, the two large derricks, with booms of 200 and 155 ft. respectively, were set directly over these main piers, from which they handled the steel centering and other materials for the 300-ft. span (Fig. 4).

Steel Centers—For the short arches the centers consisted of three-hinged steel truss arch ribs, each rib supported on I-beam bearings, resting on I-beam cantilevers projecting from the face of each pier. A sufficient number of these ribs was set up in a span to erect two concrete-arch ribs—that is, one-half the width of the bridge—then the steel centers were moved horizontally on the supporting beams to serve in casting the other half of the span. Horizontal steel tie cables connected the end hinges of each steel rib. When one small span was thus completed, the centers and superposed lagging were lowered, picked up by a derrick and set in the adjacent span.

Centers for the 300-ft. span were in reality five-hinged arches, but their position in construction made them act as three-hinged. Except for a rare combination of symmetrical loads and reactions, for which the true-equilibrium polygon or line of pressure passes through all five hinges, this type of arch is unstable. As used in this bridge, however, the crown and two intermediate hinges served to make the three upper portions of the arch act as true three-hinged construction, while the lowest sections merely served as supports for the three-hinged portion. This was made possible as follows: the entire centering for the 300-ft. span consisted of two groups of trussed ribs, each group composed of three five-hinged arches thoroughly braced together and braced to the second group (Fig. 5). One group was placed under the north (downstream), or exterior, main-arch rib; the other under the north interior rib. Each arch of these centers was supported on wedges resting on a series of I-beams extending parallel with the river, and was supported by steel-trussed seats built into and projecting from the water side of the main piers. To take the horizontal thrust at these supporting points, the trusses abutted against the sides of the pier previously built. At each intermediate hinge the tendency to move outward was resisted by allowing the trusses to bear against a series of horizontal I-beams abutting against the soffit of the umbrella. Thus the lower section of each five-hinged arch was made stable by contact with the umbrella at two bearings. On these supporting sections the real three-hinged arches were supported; and the otherwise unstable five-hinged structure became stable.

The various sections of the ribs were erected as cantilevers by building out

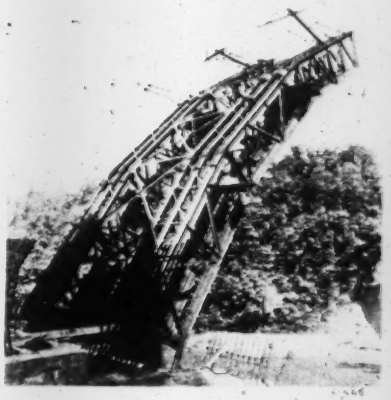


Fig. 5—Steel centers were erected by cantilevering progressively from the abutments, utilizing cable tiebacks.

from each main pier, with the upper projecting ends tied back with cables to the completed pier superstructure (Fig. 5). The shop-riveted sections of each truss were field-connected by bolts.

Upon completion of the two north ribs the filler wall was cast between them. Then the centering was slightly lowered at the wedges, moved upstream in position to build the two south ribs and the filler wall between them. Finally, all centering was moved north again to support the construction of the central section of filler wall, after which the entire centering was moved parallel to the river until each truss in turn was outside the limits of the bridge width, when it was dismantled with the aid of temporary cantilevers projecting over the side of the finished concrete. After all centers were removed in this manner, the trussed-steel supporting seats were flame-cut from the faces of the main river piers, and belt courses of granite facing were inserted.

Estimate and Cost—The engineer's estimate, made in January, 1930, just before proposals on the project were

opened, was $2,948,200; an amount 5 per cent above the $2,801,841 average of all nine bids opened subsequently. The successful lump-sum bid was $2,494,012, and the contract period was 24 months. Extras amounted to $110,039.26, or 4.4 per cent of the contract price.

Personnel—Ridge Road bridge, like all structures of this magnitude, is not the work of any one man but is the combined effort of many mental as well as physical workers. The main features of the structure represented the results of joint study by Frank P. McKibben and the architects Gehron and Ross; in the reinforced-concrete structural work Meyer Hirschthal was the chief designer of the bridge as built and of several preliminary studies in concrete; L. H. Shoemaker's excellent assistance in making early designs for steel arches in comparison with those in concrete is of note. Representing Frank P. McKibben in Rochester, Richard de Charms served as resident engineer.

The contractors were Booth & Flinn, of Pittsburgh, George Hockensmith vice-president, and H. N. Crichton superintendent. Representing the city of Rochester were City Manager Stephen B. Storey, Commissioner of Public Works Harold W. Baker, and Edwin A. Fisher, C. A. Poole, H. L. Howe, Jr., and W. H. Roberts of the city's engineering department.

After its completion the Ridge Road bridge was named Veterans' Memorial Bridge by the municipal council.

Long-Span Steel Framing in Pittsburgh Building

New 37-story Gulf Oil building contains no columns in rentable space in tower, utilizes double girders and three-web columns and provides for removal of some alternate floors to give rooms two stories high and 38x100 ft. in plan

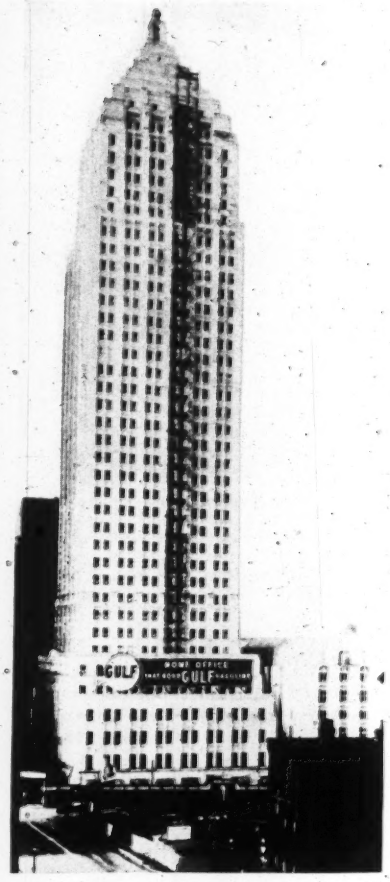


Fig. 1—New 37-story Gulf Oil building in Pittsburgh. Small building at right is new Federal Reserve Bank, in which roof, entablature and spandrels are of aluminum. Excavation in foreground is for new post office and federal building.

THE NEW 37-story Gulf Oil building in Pittsburgh, Pa., is unique in that no columns occur in the rentable space in the 30-story tower portion. To achieve this result, columns are grouped around the elevator and service areas that form the core of the building, and double girders span between these columns and the wall columns, a distance of 36 ft. in the corner panels of the building. Large column loads result from this type of layout, and a special three-web built-up column section was developed as being superior to heavy rolled sections with coverplates. Among other interesting structural arrangements in the building is provision for removing some of the upper tower floors to provide two-story radio-broadcasting studios. The foundations also are somewhat unusual in that large pneumatic caissons, carrying in two instances as many as six columns, were carried to rock at about 70 ft. below the curb.

The finished building is of monumental character, faced with limestone. In ground dimensions it is 195x130 ft., reducing by setbacks (at the fifth floor on the east and west sides and at the seventh floor on all four sides) to a tower 108 ft. square, which rises to the 32d floor. Above this elevation another series of setbacks brings the roof dimensions at the 40th-floor level, below the lantern, to 55x55 ft. The total height of the building is 572 ft. Floors are of terra cotta arch construction, with 10-in. filler beams forming a flat ceiling.

The final adopted framing plan was an evolution of the structural studies, for the first architectural sketches provided only for a standardized grid layout with panels about 20 ft. square. The first revision involved elimination of the first interior column at each corner, to provide unobstructed space in these areas. This done, it suggested the further revision of moving the remainder of the columns in this first interior row on the east and west sides of the building back to the wall that surrounds the elevator shafts and service areas. The result was that all interior columns were placed either in an elevator or corridor wall, and that the rentable area of the building was left entirely open.

Foundations

Basement excavation was carried to a depth of about 32 ft. below grade over the entire site. The foundations established at this elevation are unusual in that all tower-column foundations are carried to a blue shale rock occurring about 70 ft. below grade, while the rest of the column piers and the continuous concrete wall that incloses the basement area utilize spread footings founded on a gravel formation from 5 to 10 ft. below the sub-basement floor. It was possible to support all but the tower columns on the gravel, since none of them is more than seven stories high.

The caissons for the tower columns were in general built of sufficient size to carry two columns each (Fig. 2). The exception to this arrangement occurs in the center of the tower portion where the six two-column caissons were so closely grouped as to suggest combining them for economy in construction. Accordingly, each set of three two-column caissons either side of the north-south center line of the building was combined, providing two caissons 18x42 ft. in plan, each carrying six of the heaviest loaded columns in the building. To save concrete and to provide access to the working chamber from two airlocks, these caissons were built with two hollow cores. After providing two-column caissons for most of the tower-wall columns, there still remained one column at the center of both the east and west walls that did not rest on a caisson. Instead of supplying foundations for these two columns to rock, they were supported

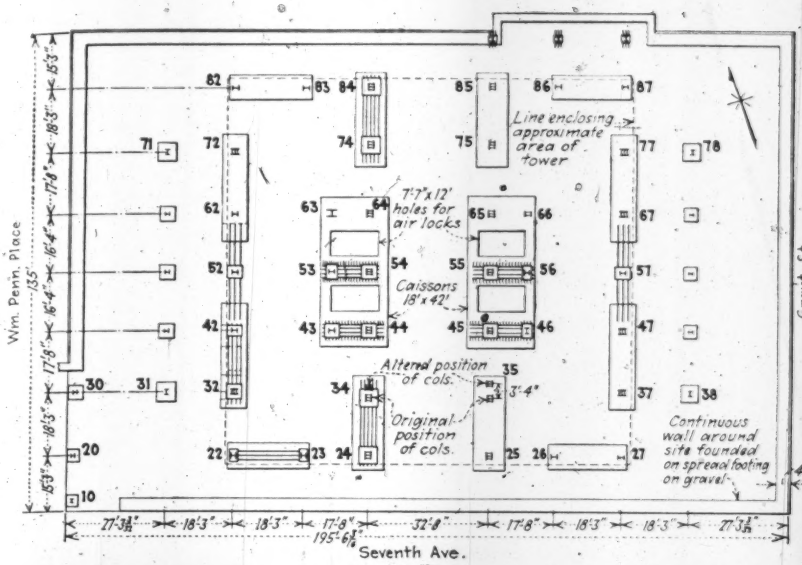


Fig. 2—Foundations of the Gulf building are of two types—in tower area compressed-air caissons carrying two to six columns each sunk to rock, and in remainder of area spread footings on gravel. Columns 52 and 57, it will be noted, are carried on girders spanning between adjacent caissons.

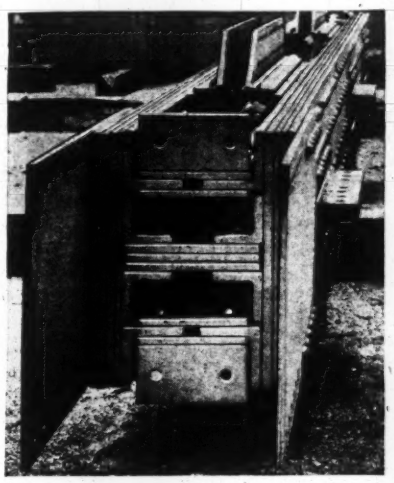


Fig. 3—Three-web column with a high ratio of steel area to total area and featuring a constant depth of 20 in. parallel to the webs regardless of load capacity.

on girders spanning between the caissons that carried the columns at either side of them.

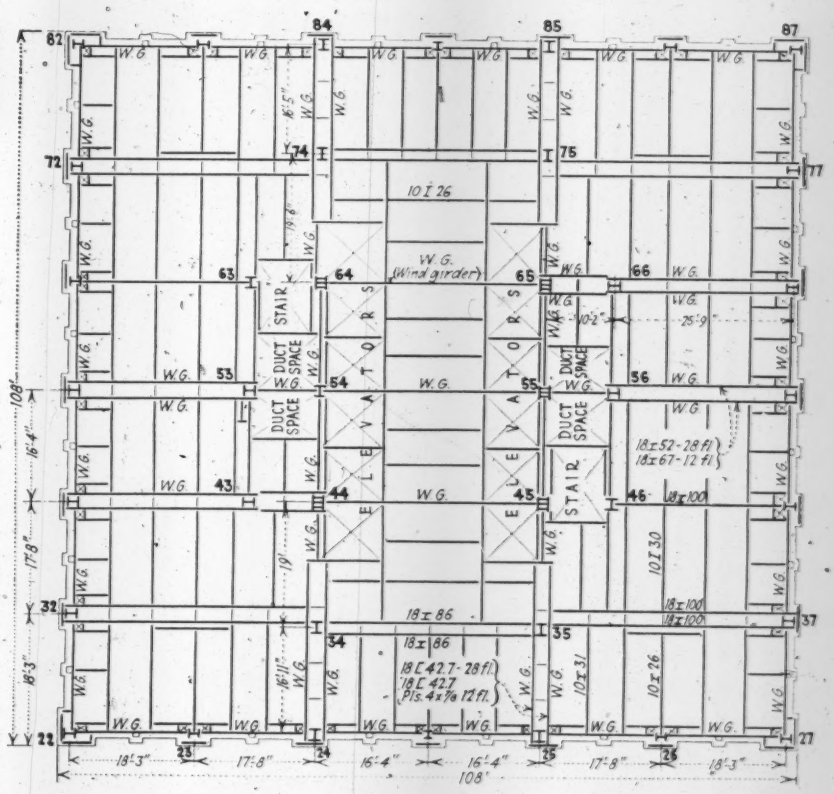
Structural framing

In the framing plan of the twelfth floor (Fig. 4), which is typical of the tower floors, the grouping of the service facilities in the core of the building and the open rentable space around it are readily apparent. The largest open panels occur in the corners and are 36 ft. square, although the other exterior bays have spans longer than the average, varying from 26 to 33 ft. The majority of the long spans run in an east-west direction and are framed by double-rolled girders (in general, 18-in. sections) straddling the columns. Typical column-girder connections are shown in Fig. 6. The heavier columns, it will be noted, are built-up three-web sections of plates and angles. This type of section was developed as being more economical than one using the heaviest available rolled H-section with coverplates (requiring shorter rivet grips for one thing) and provided the additional advantage of a constant depth (in this building 20 in.) from bottom to top of the column. Thus column 45, one of the heaviest loaded columns in the building (2,767 tons), has an area of 372 sq.in. at the bottom and 202 sq.in. at the 30th floor, but the three-web arrangement and the depth of 20 in. do not vary, as shown in Fig. 6. This constant-depth feature is particularly useful in elevator-shaft walls, and it is in this location that most of the three-web columns occur in the Gulf building.

The tower of the building being approximately square, wind resistance had to be provided about two axes. A wind pressure of 30 lb. per sq.ft. was used in the design. In a north-south direction there are four bents, and in an east-west direction three bents extend completely through the building. In addition, in an east-west direction there are two bents designed for wind, which extend only about three-fourths through the building, being interrupted by stair wells. In the wind design no account was taken of the bracing effect contributed at the bottom where the tower merges with the large base of the building.

Windbracing is of several types. In

Fig. 4—Steel-framing layout in Gulf Oil building utilizes double-girder spans up to 35-ft. length, permitting all rentable space from windows to interior walls to be free of columns. Service area is concentrated in core of building. Wind resistance is provided about both axes.



the service areas and toilet rooms, kneebraces are utilized, made shallow so as not to restrict headroom. In the elevator-shaft walls, kneebraces of full-story depth are used exclusively. In the rest of the building the deep gusset connections, possible with the double-girder arrangement, provide the necessary rigidity. On columns that carry wind in both directions, kneebraces are generally used in at least one direction.

Special layouts

Several unusual structural layouts occur because of special requirements. Among them may be cited a "bent" column, several trusses, some cantilever girders and an arrangement whereby several floors may be removed if a tenant requires a two-story room.

The bent column resulted from a change in lobby layout after the foundations were built and the steel design completed. The change necessitated moving columns 34 and 35 3 ft. 4 in. north in the section between the basement and the second floor (Fig. 2) and then keeping them in their original position from the third floor upward, since it was not desirable to disturb the original layout of the steel in these upper floors. Fortunately, each of these columns rested on one of the large two-column caissons and the shifting did not appreciably affect foundation stability. It was a simple matter to incline the columns between the second and third floors, bringing them back to their original position. In effect, the arrangement is a triangular truss in which one member (the column) is a three-web section.

Two other trusses span the entrance lobby, one in the second floor between columns 84 and 85 and one in the third floor between columns 24 and 25; both of these trusses carry a tower column at their mid-point. A third truss, with parallel chords, spans between columns 14 and 15 above the third floor, whose function was to carry, by means of rods hung from the lower chord, a 68-ton stone over the south entrance and the panel of wall above it. This stone, however, was given a 6-ft. bearing at either end and was found to be able to support itself as a beam, permitting the omission of the rod hangers.

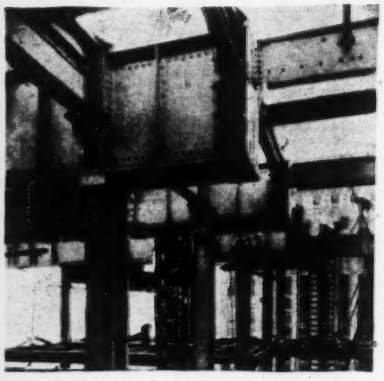


Fig. 5—Girders at 32d floor cantilevered over elevator shafts that are discontinued to permit columns above to be set inward 6 ft., increasing rentable space in floors 32 to 36 inclusive.

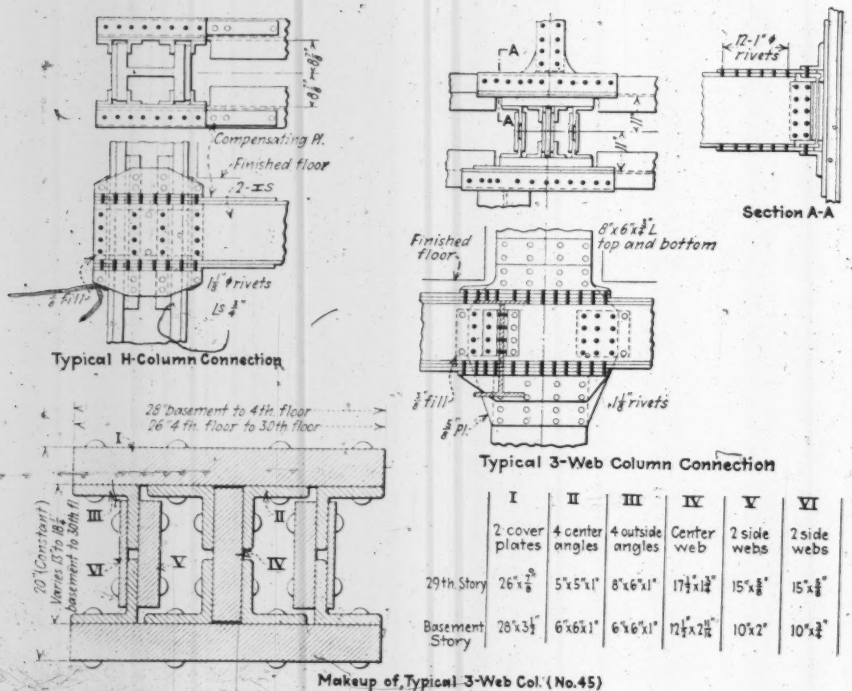
At the 32d floor there is a general setback of all exterior columns. Two three interior columns (45, 55 and 65) are set back, since the elevators on this side of the building run only to the 30th floor, and this shifting of the columns increased rentable space in the area of floors 32 to 36, inclusive. These columns, loaded to as much as 1,040 tons each, are carried on the ends of 42-ft. girders 68 in. deep, cantilevered 6 ft. over the elevator shafts below. These girders (Fig. 5) have a 1-in. web, 8x8x1⅛-in. flange angles and 17x2⅝-in. coverplates.

As a result of this setback there is a space 38 ft. deep from window to interior wall along the east side of the building in floors 32 to 36, inclusive.

Inasmuch as it is possible that broadcasting companies may be acquired as tenants, provision was made in this section of the building for the removal at a later date of any floor or any two not adjacent from the 33d to the 36th. Any of these arrangements would provide a room two stories high, 38 ft. wide and nearly 100 ft. long, entirely free of columns.

The foundation and structural-steel designs for the Gulf building were made by Weiskopf & Pickworth, consulting engineers, New York. Architects were Trowbridge & Livingston, New York, with E. P. Mellon as associate. The Mellon-Stuart Co. was the general contractor, Booth & Flinn were foundation contractors, the McClintic-Marshall Corp. was steel fabricator, and the John E. Mullen Construction Co. erected the steel.

Fig. 6—Girder connections and column makeup in the Gulf Oil building. Placing girders on outside of columns permit deep gusset connections to develop wind resistance. The constant 20-in. depth of the three-web columns from bottom to top of building is notable and useful in elevator shafts.



	I	II	III	IV	V	VI
	2 cover plates	4 center angles	4 outside angles	Center web	2 side webs	2 side webs
29th Story	26"x1⅝"	5"x5"x1"	8"x6"x1"	17½"x1⅜"	15"x⅝"	15"x⅝"
Basement Story	28"x3½"	6"x6"x1"	6"x6"x1"	17½"x2⅝"	10"x2"	10"x1¾"

Large Canal Under Construction in Belgium

Construction of a canal 127 km. long, from Antwerp to Liége in Belgium, is now under way, according to *Le Génie Civil* (March 5, 1932, p. 255). The present navigable route from Liége to Antwerp traverses the Meuse River and numerous canals, extends in part through Holland, has a total length of 253 km., requires passage through 24 locks and takes twelve days to make the trip. Further, it is limited to barges of a capacity of 450 tons.

The new canal will reduce the actual distance to 162 km. (100 miles), will reduce the number of locks to seven and will provide for barges of a capacity of 1,300 tons. The new canal is to have a width of 20 m. (65 ft.) and a depth of 3.5 m. (11.5 ft.). As this canal is to take its water supply from the Meuse River at Liége the level of water in the canal cannot be raised above El. 197, the level of the river at that point. This will require making a cut nearly 200 ft. deep through a ridge lying west of Liége and will involve moving 32,000,000 cu.yd. of earth.

Demoralization and Reorganization in the Cement Industry

Present conditions, their causes and effects, with some suggestions for a practical realignment of production facilities to insure more efficient and economical distribution and better protection for the consuming public and the investor

By O. Fred Rost
Marketing Editor, The Business Week

—In two articles

II—*Reorganization by Regrouping Plants*

IN THE preceding article a brief sketch of the cement industry and its present state of disorganization was given (*ENR*, March 17, 1932, p. 404). The losses of the industry in 1931 were estimated at more than $25,000,000. Indications from early bidding for 1932 requirements are that the price trend is still downward and that even greater losses may be shown this year.

Declining demand coupled with unbridled competition for the available orders, driving prices still farther below cost of production, spells ruin. What is the solution? Attempts at cooperation have failed up to now. Even the earnest efforts of leaders of the industry to bring about a sane business view have proved abortive. The industry is drifting in a dangerous current.

The way out lies in reorganization of such kind as to assure more efficient distribution and to establish healthy competition in all parts of the country. This development is as greatly in the public interest as in that of the industry, for it has never been found advantageous to the public weal to permit an industry to sell its product for a sustained period of time at less than cost. Selling below cost is even now under investigation by the Federal Trade Commission, and quite possibly may yet become the subject of federal legislation.

Whoever is familiar with the strong character of the leading executives of the cement industry will find it difficult to understand the conditions that have come into existence. The simple fact is that the same executives who guided the technical problems of plant and production along a course of steady advance have, since 1929, in steadily increasing measure dissipated the reward in the field of distribution by participating in reckless competition. They have drained their companies' resources and allowed the business of selling cement to degenerate into a free-for-all scramble for tonnage at any price.

The decision to include in the present series of articles on the distribution of construction materials an outline of plans for a more practical realignment of the cement industry was reached after a study of its present methods of distribution had developed the fact that the cement industry as such offers a typical and remarkably clear opportunity for outlining a better-balanced and more efficient system of distribution. Achievement of this objective involves some heroic measures, however.

With cement production in 1931 at 46 per cent of capacity and with further declines in prospect, it is reasonable to assume that for some few years the industry will be unable to employ profitably more than one dollar out of every two that are invested in it. Consumption is unlikely to absorb the potential production for fifteen or twenty years to come, and this means that present investments in the industry cannot be expected to earn reasonable interest for many years, unless drastic remedial measures are adopted.

It follows that realignment of producing capacity for more economical distribution must include provision for the allocation of present surplus ca-

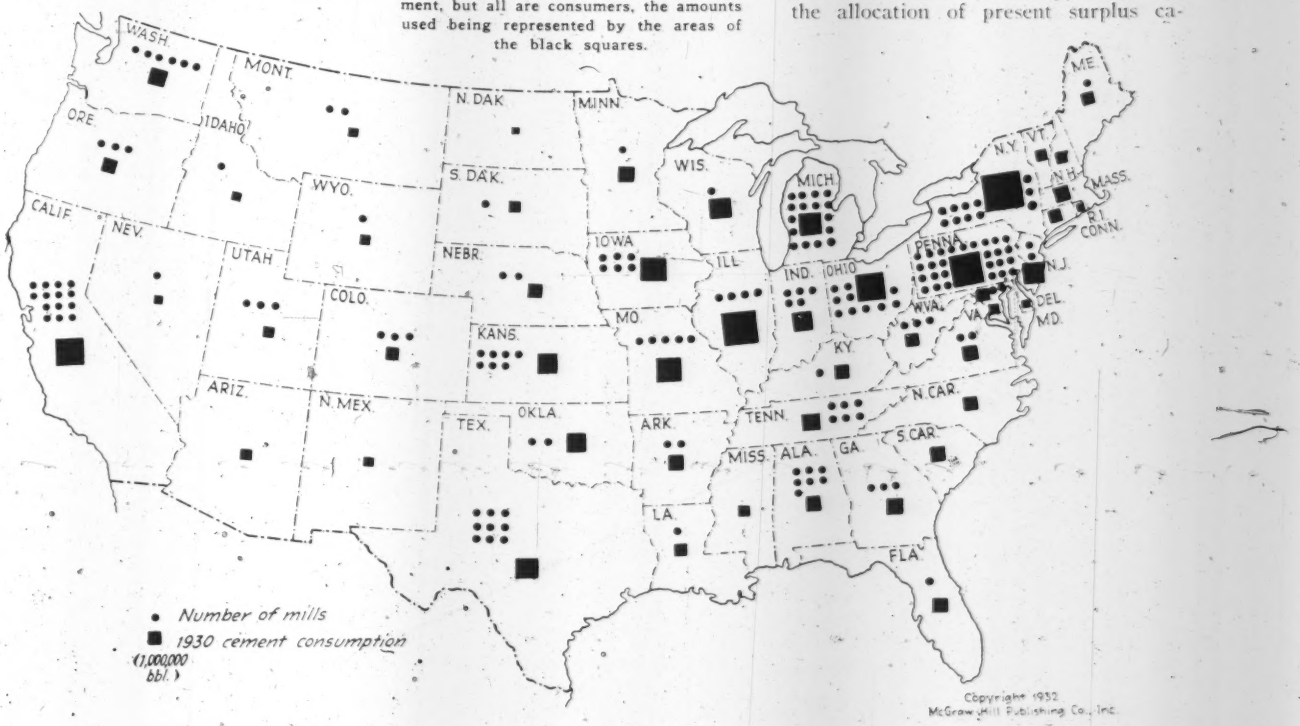


Fig. 1—Portland cement production and use in the United States (1930 figures used). Twelve states produced no cement, but all are consumers, the amounts used being represented by the areas of the black squares.

pacity among those producers who are definitely equipped to carry it through the period that lies ahead. They would release available equipment to productive activity only when and as such action is justified by increased consumption. In the interim they would supply current demand from plants that are kept running at 85 per cent or more of actual capacity, so as to enable them to attain a high production economy and to insure low costs, giving the consuming public the benefit of minimum prices.

Experience has conclusively demonstrated that the greatest effectiveness and economy in the distribution of any product, as well as the lowest possible prices to the public, are generally achieved in those fields where there exists at least one large company that accomplishes national distribution under the control of a single directing organization. Examples in support of this contention are readily found in a number of important industries. But in the cement industry, singularly enough, there does not exist a single organization that can claim even an approach to national distribution of its particular brand of cement.

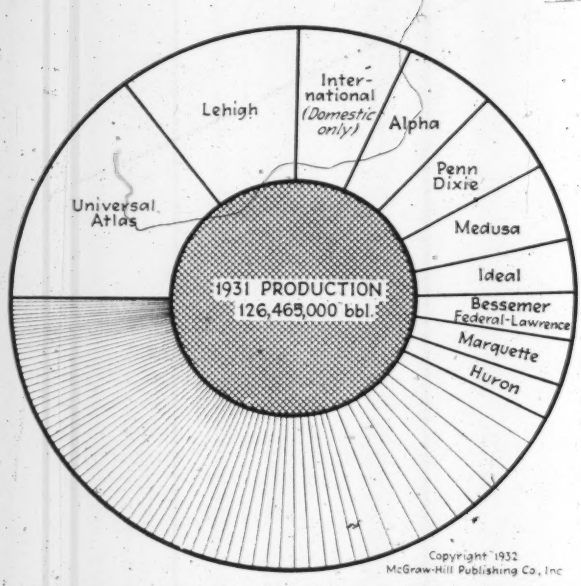


Fig. 2—Structure of the portland cement industry, showing number and comparative size of active producing companies. The circumference of the outer circle represents the total producing capacity of the industry, and the widths of the slices represent the capacities of the several companies. Actual production in 1931, represented by the inner circle, was less than half capacity.

What kind of reorganization?

The largest single unit, the Universal-Atlas Cement Co., can serve economically only a comparatively limited portion of the national market from the producing plants that it now owns. It therefore appears logical that the cement industry might achieve some degree of relief from its present state of demoralization and attain more orderly and economical distribution if it were to create a few large, independent and nationally operating companies that would be in direct competition with each other as well as with a large number of smaller companies that would continue to operate and serve in various areas within the economical shipping radius of their plant.

The plans that are presented herewith have been prepared for the purpose of reaching the following definite objectives:

1. To reduce economic losses caused by the present state of disorganization and to prevent future more serious losses.

2. To protect as far as possible the rights of the public as stock and bond holders in cement-producing companies.

3. To preserve open competition in all areas.

4. To give assurance that cement will be obtainable at the lowest practicable price.

It should be borne in mind that the plans and procedures herein proposed have been developed as the result of observations and studies made by an entirely disinterested party. The organizations and individuals that collectively represent the cement industry as of 1932, their producing equipment, financial capacity and executive abilities have been considered solely and entirely in the abstract. Every possible effort has been made to avoid any suggestion that, if carried out, might lead to a monopoly or to the control of the industry by a comparatively small group. It is fully realized that no plan can long endure if in its application it interferes with free and open competition between all manufacturers. The plans here proposed are based on the conviction that open competition can best be maintained if small, well financed, ably managed units are continued in individual operation in every important marketing area.

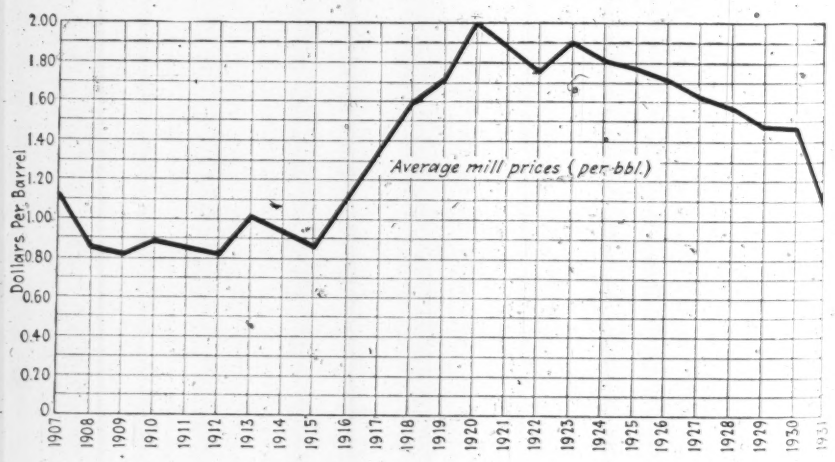
Any program that may be projected for the realignment of the cement industry can at this time be considered seriously only if it does not involve the great amount of new financing and if instead it provides a way by which the money already invested in the industry is made more secure and may be expected to produce reasonable returns. Naturally such results cannot be accomplished if various plants continue under individual ownership, but they may be obtained if a number of plants are combined.

Money, men and plants

In any new grouping of cement companies the problem of manpower will be found particularly serious. Men who have been intimately associated with the upbuilding of the industry and who are intensely individualistic will naturally be reluctant to subscribe to a plan that would involve their submergence in the common interest of a larger group. Any successful plan of procedure must recognize this problem and provide equitable adjustment.

The cement industry today comprises nearly 200 separate plants. Some older plants are being kept in operation and are considered worthwhile by their present owners because they figure only the actual upkeep in determining production costs and disregard normal charges for depreciation. Nevertheless such plants form an important factor in the industry and represent a considerable portion of its production capacity.

Fig. 3—Below and on the opposite page is shown the history of cement prices as compared with production and capacity, reproduced with corrections from the previous article (*ENR*, March 17, 1932, p. 405). Particularly noteworthy is the abrupt drop of the price curve from 1930 to the 1931 figure, matching a similar drop in the amount sold. The price drop was not shown correctly in the earlier article due to a plotting error.



In the hands of a large, nationally operating company some of these older plants would be closed or modernized.

Wastes in selling

Wherever there is a sizable contract for cement in prospect, there eight or ten cement sales organizations send their sales managers, assistant managers, district managers and their salesmen. Such procedure appears particularly wasteful when it is remembered that all the companies are actually selling a product that is presumed to be so highly standardized that if all the different brands of cement were, without marks of identification, submitted to laboratory and practical tests, there would be little or no difference in their conformity to specifications and the ability of the material to perform the purposes for which it is being bought.

Under the present set-up of the cement industry, and for that matter in any other industry, the burden of expense of all the operating departments is of course included in the selling price. Any plan for realignment must provide for a substantial reduction in the waste of selling, and yet insure adequate competition.

Plan 1, for quick action

In the preparation of the following proposals for a realignment of the cement industry every effort has been made to keep in mind the factors that have already been recited. Consideration has also been given to the obstacles that naturally confront any organized attempt to improve conditions in the industry through a realignment of production capacity or through what will substantially constitute a series of mergers. The three plans that are herewith submitted should be considered progressively, in that they provide varying and successively increasing degrees of centralization of production control, through which successively increasing balance and economy in distribution may be obtained.

In the territory east of Colorado there are about 70 cement companies. Six of these control half of the producing capacity, but not one of the six has plants so located that it could supply economically the requirements of the entire territory. Yet any one of the six could without any substantial increase in its general overhead perform the sales and distributing activities more completely in the entire region.

Under plan 1 these six large companies would take over certain smaller companies that are now operating with varying degrees of economy in various territories. Such consolidation would provide production capacity in territories where the larger company has not now adequate or suitable production capacity for serving the market economically and efficiently. In some instances the smaller plants have been grouped with larger units, even though they actually increase what appears to be ample capacity for the district; this procedure has generally involved plants that are today either antiquated or at least uneconomic in operation but that have nevertheless been a factor in contributing their share to the industry's state of overcapacity.

Under this plan 32 plants now operating independently would be merged with one or the other of the six large companies. These six large companies would then control about 73 per cent of the production capacity in the eastern territory, while the remaining 27 per cent of capacity would be in the hands of thirty-odd independent companies so located that practically no marketing area east of Colorado would be without competition from small individual companies—in addition to the competition that would of course exist between the six large companies.

It is obvious that with this increased number of plants under their control the six large manufacturers will be better able to organize their production on a basis where they will have certain plants closed down entirely, while others will operate at high economy and make possible the lowest practicable selling price.

A second plan for a realignment of the cement industry has been prepared on a countrywide basis and from the standpoint of extending the usefulness of already-existing organizations so as to effect greater balance between production and distribution through the formation of nationally operating units that would parallel those found in other important industries. It follows that this plan provides for much larger units and leaves a lesser number of individually operating companies.

Plan 2, five countrywide systems

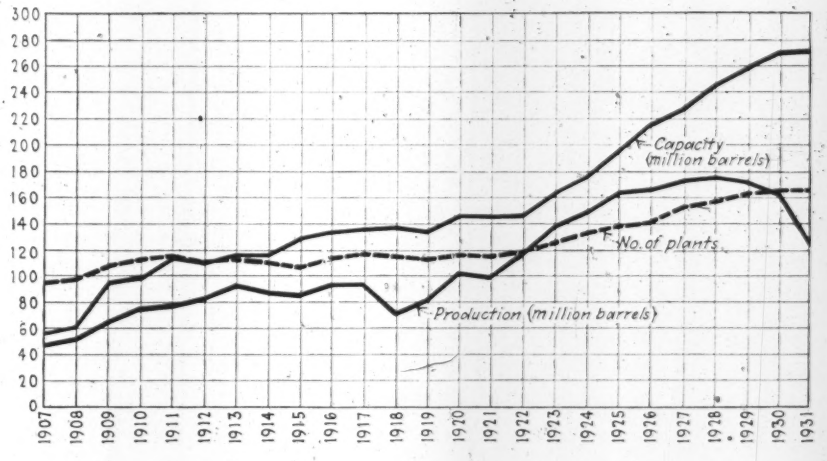
Certain particular advantages reside in plan 2. It would make possible the elimination of an unusual amount of unproductive expense that is now carried in great duplication by each of the various companies. Also, by concentrating more producing capacity in the hands of the larger units and extending their operations over a much larger territory it would promote economy and flexibility of operation. The chance of earning a profit for all the stockholders would be improved.

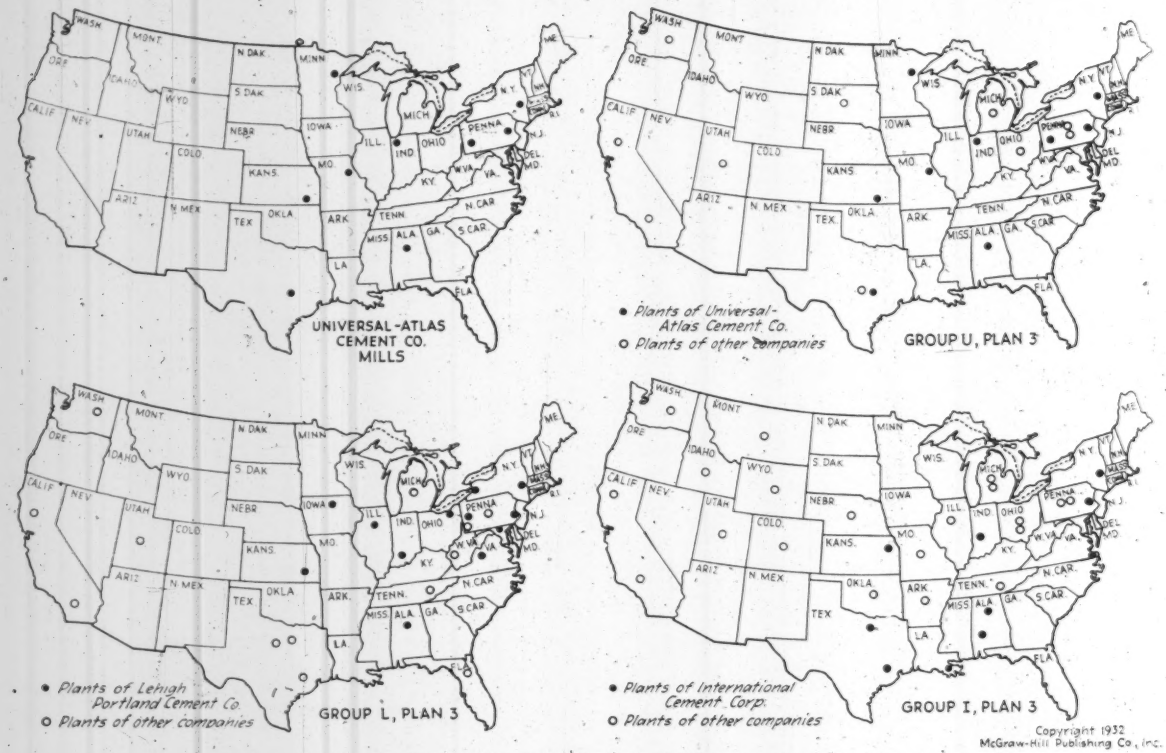
It must be emphasized again that this plan is much more far-reaching than plan 1, on the theory that the industry as a whole can get back on a profit-making basis only if the actual production of cement is concentrated in a lesser number of plants, which would supply current requirements while operating at nearly maximum capacity and thus achieve the utmost in operating economy.

A further grouping is presented in plan 3. It differs from both plan 1 and plan 2 in that its preparation has been approached from a somewhat different angle. The earlier plans took into consideration present managerial, production and financial equipment of the various component companies and then outlined groupings that might be accomplished in fact and could reasonably be expected to develop into satisfactory operating units, involving the smallest number of mergers. In plan 3 this obstacle of mergers has been to an extent disregarded.

Plan 3, for three large groups

While financial, productive and executive questions were not left entirely out of consideration, plan 3 was prepared primarily to represent what might be called an ideal alignment for efficient distribution. It provides for only three large nationally operating units. It is believed that all the requirements of present laws can be met with only three large nationally operating companies as long as there are numerous small companies in the field to provide independent small-unit competition against that of the nationally operating companies in the variously marketing areas. Even with only three major units the cement industry would not be as greatly centralized as certain other major industries where centralization has progressed farther.




UNIVERSAL-ATLAS CEMENT CO. MILLS
• Plants of Universal-Atlas Cement Co.
o Plants of other companies
GROUP U, PLAN 3
• Plants of Lehigh Portland Cement Co.
o Plants of other companies
GROUP L, PLAN 3
• Plants of International Cement Corp.
o Plants of other companies
GROUP I, PLAN 3

Copyright 1932 McGraw-Hill Publishing Co., Inc.

Figs. 4 to 7—As the industry is now organized, the individual units can serve only comparatively small parts of the country economically. For the largest producers this is shown by Fig. 4, the location of mills of the Universal-Atlas Cement Co. More complete systems can be set up, as shown in Figs. 5 to 7.

Plan 3 also provides for increasing the intensity of competition with the importance of the marketing area, so that in the territories of heavy cement consumpion some large and well-organized companies would continue in their present status of individual operation. If the obstacles involved in the actual consummation of mergers were less complex, plan 3 might be recommended for the most serious consideration of the industry. It would yield to the industry, to the owners of cement securities, as well as to the public at large, the most valuable and lasting benefits.

Valuation problems

Mergers necessarily imply valuations. Without attempting to supply a formula for arriving at a fair valuation of existing cement plants, this article may enumerate some of the factors that both the seller and buyer of cement plants must bear in mind if any resulting merger is to serve its best purpose. The factors that deserve the most serious recognition in this connection are the following:

First, with actual production for 1931 at 46 per cent of capacity, valuations of cement companies as of 1932, if based on their potential market, must be written down to 50 per cent of their former value.

Second, while 50 per cent is suggested as an average, it is quite possible that some plants, because of their advantageous location from a producing standpoint or their proximity to an important and exceptionally promising marketing area, or both, might justify a higher valuation.

Third, there are many plants which, because of the physical condition of their producing equipment, the remaining supply of raw materials, the proximity to other more efficiently operating plants and the general outlook for business in the particular territory served by them, might, even if bought at 30c. on the dollar, result in actual loss to the buyer.

Fourth, the art of making cement has improved materially, and it is obvious that a company manufacturing cement in an up-to-date plant will not buy at high valuation a plant that has become obsolete and uneconomical in either location or equipment.

Fifth, it would be unreasonable to base the valuations in connections with a 1932 merger on past performance or the dividend record of former years, in that, under prevailing conditions of extreme overcapacity and the existing state of disorganization in the industry and the present outlook for the future of the cement industry, such performance as is reflected in the past record of any cement company cannot again be duplicated in many years to come.

Sixth, an emergency exists that warrants the adoption of extreme measures if serious difficulties are to be averted.

The test of practice

Those concerned in the welfare of a cement-manufacturing company or the industry as a whole, or those who are particulary interested in safeguarding the rights of the public, may at this point advance the argument quite justly that the plans of realignment that have been proposed may look well on paper and sound well in theory, but that reasonable assurance of their successful operation in actual practice is completely lacking. It so happens that an analysis of the performance record of a few cement companies for the years 1930 and 1931 provides useful supporting evidence. The analysis includes all companies from whom a 1931 statement could be secured at this writing, except one company operating under conditions not fairly comparable.

It has already been stated that the earnings of some of the important cement manufacturers were cut in half between the years 1928 and 1930. Just how drastically that decline in earnings continued during 1931 and how seriously the losses are piling up under prevailing conditions is indicated by the statement of seven companies included in the following analysis. Those seven companies represent a total of 72 million barrels of annual capacity, or well over 25 per cent of the total capacity of the industry. Available records indicate that the seven companies have a total of 2,812,000 shares of capital stock.

Two of the seven companies are classed among the country's largest ce-

ment manufacturers, and they operate about as many plants as do the other five companies, but the plants of the two companies average only 1,290,000 bbl. annual capacity; while those of the smaller five companies average 1,560,000 bbl. In the absence of definite figures on the quantity of cement actually produced by each of these companies, it will here be assumed that each obtained such volume of business as would be its share if its operation proceeded at the average ratio of the entire industry.

On that basis the earnings of the two large companies for 1930 were at the rate of $0.195 per barrel. These companies still showed a profit for 1931, although their earnings dropped down to $0.0358 per barrel on the assumed total of shipments.

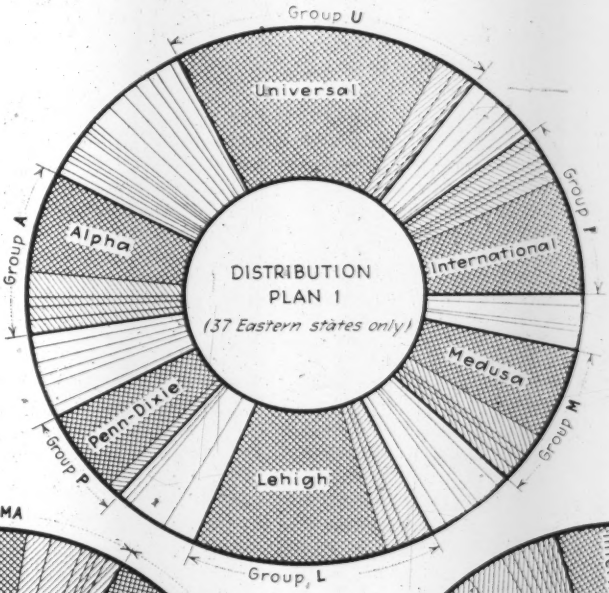
The other five companies did not fare as well. During 1930 their average earnings still approached those of the two other companies, and on the assumed total of shipments they averaged $0.174 per barrel. But in 1931 each of these five companies showed a substantial deficit, which on the assumed total of shipments represents a loss of $0.19 per barrel. It does not require the powers of an oracle to foretell what will happen if the present state of demoralization is permitted to continue while consumption and price continue to go down.

However, this analysis brings into strong relief the advantages that under present conditions would accrue if large-group operation in the cement industry could be extended. With the number of plants and the total rated capacity of output of the two groups sufficiently alike to justify comparison, it is seen that the two large companies were able to earn a small profit even under present demoralized conditions, while the other five companies sold their entire output for 1931 at an average loss on their assumed shipments of $0.19 per barrel.

Interpreted for the benefit of the stockholders who own the 1,800,000 shares of stock in those five companies, this 1931 performance record means that they contributed about $2 per share in operating losses for the privilege of having the standardized product of their factory sold at 19c. per barrel less than it cost their factory to produce. A considerable part of this important difference in operating results may be traced to the fact that on comparable volume of shipments the group that still earns a profit supported only two complete organizations, while the other group carried the burden of supporting five. Further, it is probable that the large companies concentrated their production in fewer plants so as to obtain the greatest possible manufacturing economies. Indeed, one of the two large companies included in the analysis stated that a number of its plants were not in operation during 1931.

Obviously, the conclusion is warranted that the theory upon which the realignment plans above presented were developed is sound, and that if any one of them were carried through in a degree approaching 100 per cent of completeness, the economies in production and distribution of cement that are claimed for operation under such realignment may reasonably be expected to materialize.

Fig. 8—Distribution plan 1 is a regrouping of the cement producers in the 37 states east of Colorado for improved efficiency and economy of distribution. The plan takes account of the principal commercial and financial factors and can be made operative with minimum difficulties in the way of new financing.



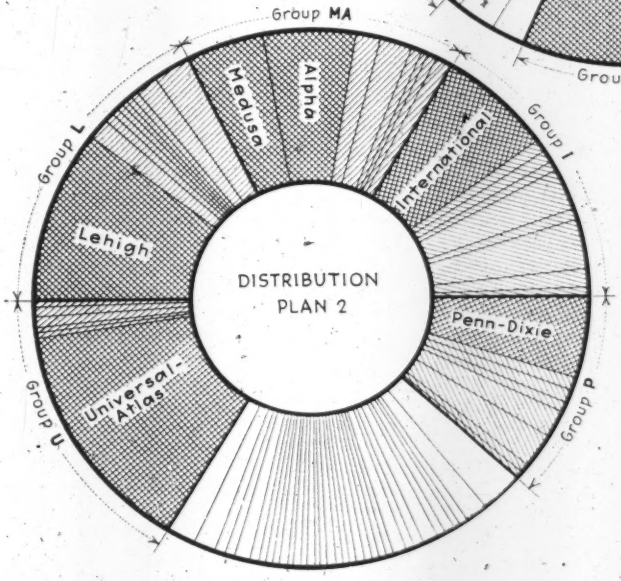


Fig. 9—Distribution plan 2, a five-system plan, covers the entire country and is so worked out as to give more economical distribution than the present plant arrangement while maintaining effective competition at all points. In addition to the five large systems, 35 companies with 46 mills would continue in individual operation, serving all market areas.

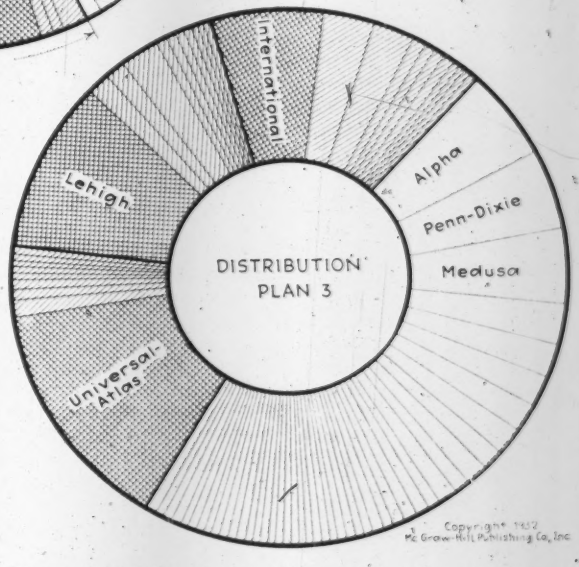


Fig. 10—Distribution plan 3 is a three-system plan arranged for greatest distribution economy throughout the country, and having 46 companies with 80 mills in individual operation, giving additional competition graded according to the importance of the various marketing areas. This plan is the most complete and comprehensive of the three shown.

Letters to the Editor

George Washington—Engineer

Sir—I am greatly interested and pleased to read your article in the Feb. 18 issue of *Engineering News-Record*, entitled "George Washington—Engineer," which gives so illuminating a picture of his most important works in this line, which of course necessarily must be brief.

I often wonder how many of our engineers have taken the trip to the Great Falls of the Potomac to observe the Washington Canal, the line of which is still discernable, and in which the deep rock cut at the lower end is still as made by Washington's assistants, and wherein one of the locks still shows the handiwork of those under the general supervision of Washington. A visit to this canal visually carries one back to the revolutionary days and to the time when Washington was actively engaged in that sort of work.

Another thought that I would like to express here is the fact as I understand it that Washington personally laid out substantially all of the engineering work in connection with his great farming interest, and that in this he probably carried on as diversified a line of engineering as can be found in any occupation. We are likely to lose sight of the fact that a farming enterprise well developed is one that means not only the acceptance of the effects of the elements with fortitude but also the laying out and construction of almost innumerable kinds of engineering work in all lines.

New York, N. Y., Feb. 23, 1932. WM. B. JACKSON.

Hydrogen Embrittlement of Wire Due to Pickling

Sir: In your issue of Feb. 25, 1932, p. 291, there is an article describing the work under way by the Utilities Research Commission and the American Society for Testing Materials in determining the cause of embrittlement in steel. The statement is made that, compared to embrittlement caused by punching, embrittlement caused by pickling and galvanizing may be classed as a minor factor.

In this connection it may be of interest to report a pronounced case that was encountered at a manufacturer's plant during inspection of a large order of galvanized chain-link road-guard fabric. The fabric was manufactured from No. 4 gage (diameter 0.225 in.) cold-drawn steel wire and was galvanized after weaving. It was woven so that sharp bends (180 deg.) were made at the ends of the pickets where they are turned back over each other to form the knuckles. Duing final inspection it was discovered that many of the knuckles were brittle and snapped off at the bends upon the application of a very slight pressure.

The brittleness was attributed to the occlusion of hydrogen during the pickling process. This conclusion seemed logical for the reason that there was no evidence of brittleness in the woven fabric before it was pickled, but brittleness was very apparent when the fabric came out of the acid solution. Observations were made to determine the effect of varying the length of time the fabric remained in the acid bath, and it was found that pronounced brittleness developed in a period as short as 30 sec.; material immersed for as long as 30 min. showed no increase of brittleness after the first 4 or 5 min. The galvanizing process seemed to have no further effect. If the material was brittle when it entered the zinc, it was still brittle when it came out.

The wire that caused most of the trouble all came from the same mill and consisted of several large shipments representing many heat numbers. Another supply from a different mill caused only occasional trouble. Shipments from a third mill caused no trouble whatever, indicating that wire from one source is more susceptible to embrittlement by pickling than wire from another source. The wire from all three of the mills showed similar physical properties and complied in all respects with the standard specifications for cold-drawn steel wire for concrete reinforcement, A.S.T.M. designation A 82-27. No chemical examination of the wire was made.

It was suggested that embrittlement caused by hydrogen occlusion would disappear after several days, but this did not prove true. The knuckles appeared to be just as brittle after several days as at the start. One shipment held in stock for two months showed no decrease in the degree of brittleness.

As a remedy for the trouble, a commercial inhibitor was added to the pickling solution but did not prove effective. The use of a pickling agent that would act on the surface of the metal without evolving hydyrogen was suggested, and nitric acid was tried. A weak solution of nitric acid containing about ½ per cent of acid was used. This solution proved effective as a pickling agent and entirely eliminated the brittleness. It was the practice at this plant, however, to run the material direct from the pickling bath to the zinc bath without washing, and it was found that the nitric acid adhering to the material increased the dross on the surface of the molten zinc. It is reasonable to assume that excessive dross could have been avoided if the material had been washed to remove the acid before allowing it to pass into the zinc.

From this we believe that the embrittlement of steel caused by the [illegible] clusion of hydrogen during pickling [illegible] muriatic or sulphuric acid can [illegible] eliminated by the use of a pickling [illegible] that does not evolve hyhrogen by [illegible] tact with iron, and that the use [illegible] dilute solution of nitric acid [illegible] pickling agent has possibilities.

Springfield, Ill., March 19, 1932. V. L. GLO[illegible] Engineer of Materials, S[illegible] Highway Divi[illegible]

Tennis Court Slopes

Sir—George C. Love, the author of the article "Sand-Clay Road Construction Applied to Tennis Courts" (*EN[illegible]* Feb. 18, 1932, p. 250), is to be congratulated on the interesting and useful information he has contributed to this subject. I feel, however, that your readers should know that the author's recommendations, on one important detail of design, may be seriously questioned by designers of tennis courts. In the seventh paragraph of his article Mr. Love makes the statement: "Lengthwise, slope should be both ways from the net or toward it from the ends." He then goes on to show that on the courts at Duke University the surface slopes about 3½ in. down from the net to the ends.

Although there is no specification to cover the slope of the court in the official rules for the game of lawn tennis, some designers have felt that the matter is of considerable importance and have for years been advocating and designing tennis courts so that the entire surface of each court shall lie approximately in a single plane, for an indoor-court level, and for an outdoor court sloping toward one side, or one end, or one corner, as conditions may dictate. On a single-plane court the slope, provided it is not excessive, cannot affect the play in any way appreciably, but two-plane courts, such as those recommended by Mr. Love, will affect the play, and with such courts a real approach to standardization of playing conditions becomes impossible.

To your engineer readers the above facts will be obvious as soon as they are pointed out, but it has been difficult to make the average tennis-playing layman appreciate them. With a ridge under the net its effective height is of course increased, and with a valley under the net its effective height is of course decreased. For example, the effective height of net can be altered as much as 1.4 in. for a serve and as much as 2 in. for a base line shot if the court slopes 2 in. between the net and the base lines. When one considers the extreme care with which most players and umpires adjust the center of the net to the exactly specified height of 36 in. above the surface immediately under it, it seems extraordinary that no attempt has been made to eliminate the very wide variations in *effective* height that are produced on courts built on two or more plane surfaces.

New York, N. Y., Feb. 26, 1932. GAVIN HADDEN, Consulting Engineer.

NEWS OF THE WEEK

Property Owners In Portland Pledge $9,500,000 Work

WITH $9,500,000 of new construction, remodeling and general improvement work in the building field pledged after a three weeks' intensive campaign in Portland, Ore., the "Portland plan" for obtaining pledges for this class of work is considered highly successful. The goal was originally placed at $5,000,000, but after a ten-day campaign by volunteer solicitors $8,000,000 was pledged and the campaign was continued with a new goal of $10,000,000.

The campaign is being conducted by the Civic Building Service Bureau, a voluntary organization designed to meet an emergency situation. It is sponsored by a number of trade and labor groups and has received strong public support from such bodies as the Chamber of Commerce, the Realty Board, city and county officials, public schools, and civic, community and women's clubs. Its effect on unemployment has already begun to be noticed in a slight lessening in relief work done by Community Chest agencies in March as against February.

In pursuance of the plan cards were distributed for signature bearing the following request:

Believing that a dollar invested in employing labor will improve business and relieve the call for charity, and desiring to help increase employment, I hereby pledge that I will, during the next six months, expend approximately $..... in improving my home, factory, store, building or grounds, by making needed repairs, additions or alterations, or by purchasing needed equipment, or by making personal purchases for myself, family or friends which might otherwise be deferred, and to encourage my friends to do likewise.

Pledges were received for varying amounts from 50c. to $1,000,000. A very few covered projects amounting to six figures. A considerable number were in the $10,000 to $20,000 range, but the great bulk of the pledges were for much smaller sums covering minor improvements to homes, commercial buildings, and grounds and gardens.

One important favorable result of the campaign has been a better public realization of the fact that accumulated expenditures, involving the employment of labor, however small individually, will tend to lift some of the burden of direct relief funds for which are approaching exhaustion.

New Orleans Has Plan to Relieve Unemployment

A plan to relieve unemployment in New Orleans is under consideration by the mayor and the city council. It is proposed to ask the citizens at the general election this month for authority to float a bond issue of $750,000, this sum to be used to employ labor in repairing streets and beautifying city property. It is purposed to use none of the money for materials, the cost of which will be borne by other funds. In this way the total bond issue will go to pay wages.

At present the welfare committee, which has been supplying work for many idle persons, is out of funds. This money was supplied mainly by tax of 5 per cent on all salaries of state and city employees. When the salaries of these employees were cut recently, the 5 per cent contribution to the unemployed fund was discontinued.

Millions for Modernization

A large increase in expenditures this spring for repairing, modernizing and reconditioning buildings is reported by the department of commerce as a result of work of its committee on reconditioning, remodeling and modernizing. F. M. Feiker, chairman of the committee, says that about 15 million dollars additional to the normal spring operations of this class will be spent this year, including 5 millions in Portland, Ore. (now 9 millions), 6 millions in Omaha and 3 millions in Duluth.

Seattle Sued for Flood Damage Below Diablo Dam

Damage claims totaling $60,051 have been filed against the city of Seattle, Wash. as a result of three floods in the Skagit River valley and in the city's Cedar River watershed, declared to have been caused by developments of the city light and city water departments.

The commissioners of four dike districts and four individual farmers of the Mount Vernon region have filed claims totaling $54,885 for the breaking of dams along the Skagit, attributed to the opening of flood gates in the city light department's Diablo Dam. In these claims the complainants charge that the washout of their dikes on Feb. 27 could have been averted had the city light department not impounded a huge volume of water back of its dam, which was released, they declared, while the floods from the surrounding mountains were running at their highest.

J. D. Ross, city light superintendent, maintains that the flood damage to the dikes would have been much greater had it not been for the Diablo Dam.

Special Session of N. Y. Legislature Demanded for Highway Appropriation

A CAMPAIGN to reach every nook and corner of New York State is now under way to demand a special session of the legislature that will make additional funds available for highway construction as practical unemployment relief. The campaign is directed by the New York State Construction Council, organized recently by representative citizens identified with the construction industry. (See *ENR*, March 31, p. 485.) Business organizations back of the drive will turn loose an army of 3,000 workers who will devote much of their time for the next few weeks to explaining the needs and merits of a special session.

"Our workers will tell our story in the office buildings of large cities as well as in the general stores of little villages," said S. A. Scullen, chairman of the Council. "They will tell it to the man in the street, the farmer in the field, the mechanic in the garage. There will be no mass meetings, no parades, no demonstrations. We are going to tell our story personally wherever we can in the kind of language that men can understand.

To provide work for unemployed

"We believe that when we have explained the facts to the people they will deluge the governor with letters indicating that they favor a substantial program of highway construction that will provide relief for thousands of unemployed and aid some of our basic industries to resume normal production.

"The unemployment situation is growing more acute. There is too much talk about relief and not enough action. We shall have to take care of our unemployed by giving them work or doles. It is better to give them highway work, even though it may cost more than doles, because the public will then get something for its money.

Higher taxes but less highway work

"Too many millions are being spent for absurd and inconsequential relief work. Ninety-one cents out of every dollar spent for modern highway construction goes to wage earners—those who work on the job and those who work in the industries that supply the materials. This is not a haphazard figure, but one that was determined after long and careful research by Thomas H. MacDonald, chief of the U. S. Bureau of Public Roads.

"In 1931 the motorists paid $71,000,000 in taxes and got approximately 1,000 miles of state highways. In 1932 they will be assessed an additional $21,000,000, or a total of $92,000,000, and get only 355 miles of state highways. There is no equity in this, either for the motorists or for the unemployed."

For 1932 the estimated receipts from the gas tax and motor vehicle fees are $92,816,400. The estimated cost of the 1932 highway program of construction and maintenance, including $5,342,506 from federal aid, is $26,842,506. In addition the counties and New York City will spend out of their share of these taxes $19,379,500, making a grand total of $46,222,006. The diversion to other uses, therefore, from the gas taxes and motor vehicle fees will be $46,594,394, more than half the total amount collected by the state.

Bill Approved Creating New York Bridge Authority

Gov. Roosevelt, of New York, has signed the bill creating the New York Bridge Authority within the state department of public works. The bridge authority is given power to issue bonds to reimburse Ulster and Dutchess counties for the construction of the Poughkeepsie bridge and to start construction of a bridge over the Hudson River from Catskill to Hudson. The bonds are to be retired out of the revenue from tolls.

Agreement Near on San Gabriel Dam No. 1

Representatives of Pasadena, Calif., the Southern California Edison Co., Ltd., and the Los Angeles County Flood-Control District have reached a tentative agreement which is expected to clear the final legal obstacles to beginning construction of the county's proposed No. 1 flood-control dam in the San Gabriel Canyon. In brief, the agreement gives the county full jurisdiction of all land and property at the site of the proposed dam as a result of relinquishments by Pasadena and the Edison company. The agreement must be ratified by the Pasadena city board of directors, the county board of supervisors and the board of directors of the Edison company. For the relinquishment the flood-control district agrees to reconstruct the Edison company's intake and conduit line for the Azusa hydro-electric plant, located north of the dam site. The county agrees to take over several acres of government land originally granted to the city of Pasadena for intended use as a part of the proposed Pine Canyon reservoir site.

Building Inspector Guilty of Accepting Gratuity

A jury in New York City last week found Rollin C. Bastress, former chief inspector of the bureau of buildings of Manhattan, guilty of accepting a gratuity. Bribery was originally charged in the indictment; but this charge was eliminated by the judge. Testimony indicated that the $1,500 in question was paid after certain building plans had been approved; nothing was brought out in the trial to indicate that Bastress had any knowledge that a gift was in prospect before he approved the plans in the ordinary course of his duties. The jury recommended clemency in view of Bastress' excellent reputation and long and faithful public service.

In his remarks the judge characterized the act as the result of conditions prevailing in the building department. He said: "From statements made here by your own counsel and the district attorney and press comments that the superintendent of buildings and the chief engineer had disappeared, undoubtedly the jury was influenced to the extent of feeling that there was corruption in the building department, in that you, by reason of yielding to temptation, became a victim and therefore a criminal under the facts of this case, but not one who persistently used your office for gain."

The respect and confidence with which Mr. Bastress has been held by his personal and professional associates was attested to by Robert D. Kohn, Raymond Hood and others. During the recent revision of the New York City building code by the Merchants Association of New York, Mr. Bastress was the city's representative and was instrumental in guiding the activities of many of the working subcommittees.

Waco Sues to Recover Loss Due to Pipe Line Breaks

Following some 60 breaks in the 5½-mile cast-iron line from a new dam on the Bosque River to the filtration plant of the city of Waco, Tex., the city has entered a citation against the engineers, contractor, pipe company and surety company. The city seeks to recover damages jointly and severally.

Allegations against the engineers are that they were not as highly trained and skilled in the design and construction of water lines as they represented that they were, and that instead of acting upon their own knowledge and skill they acted upon the representations and recommendations of the contractor and the pipe company. It is alleged that the line has lighter bells and contains 185 tons less metal than called for in the specifications, that the city was not aware that the lighter pipe was being used, that the engineers on Sept. 23, 1930, represented that the line was ready for acceptance and, although there had been some trouble with broken pipe when the earlier tests had been made, that there was every evidence that the line had been well laid and that the city could safely accept it when such was not the case.

The city paid $366,818.84 on the $418,000 contract of May 25, 1929. The present line is called "worthless" by the city. Even if it had been constructed according to design and specification, the citation states, it would not have been of greater value than $200,000 because of the expense incident to maintaining it.

Floyd & Lockridge, Dallas, are the engineers. The W. E. Callahan Construction Co. was the contractor. The U. S. Pipe & Foundry Co. furnished the pipe. The Fidelity & Deposit Co. of Maryland was the surety company.

Baltimore City Plan Commission Named

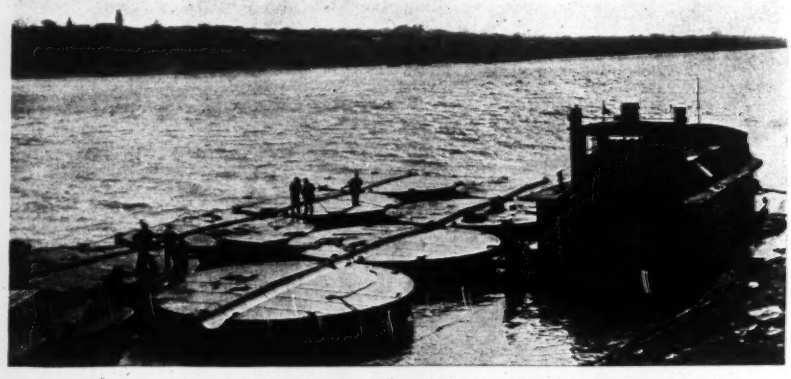
Members of the new commission on plan appointed by Mayor Jackson, Baltimore, have been confirmed by city council. Joseph W. Shirley, engineer, who has served the city in an engineering capacity for many years, has been designated as chairman. The other members are E. McClure Rouzer, attorney; Clarence W. Egan, consulting general claim agent of the Baltimore & Ohio R.R.; and William W. Emmart, architect.

A recent ordinance, passed by the city council at the request of the mayor, made the members of the board of finance commissioners members of the plan commission for joint supervision over the expenditure of municipal funds for all purposes. The joint body will supervise the preparation of the annual ordinance of estimates, so far as the appropriations in the aggregate are concerned. It also will pass on bills to be submitted to the Maryland general assembly for the purpose of authorizing future loans for public improvements in Baltimore.

Kirkbride Made Chief Engineer of Southern Pacific

W. H. Kirkbride has been appointed chief engineer of the Southern Pacific Co. Pacific Lines, effective April 1, succeeding the late George W. Boschke. His headquarters will be in San Francisco. Mr. Kirkbride advances from the position of engineer, maintenance of way and structures, which he has held since 1920.

Soon after his graduation from Stanford University with the "pioneer class" of 1895, Mr. Kirkbride became assistant chief engineer in charge of location and construction of the Sierra Railway of California from Oakdale to Sonora and Tuolumne, and later assistant engineer in charge of the field party locating the projected Shasta Mineral Belt Railway from Anderson to Alturas, in California. Going to the Southern Pacific as an assistant engineer in 1902, he held various positions in the engineering department. He was assistant superintendent of the company's Sacra-



PONTOONS FOR GOVERNMENT DREDGE WORK

These eight large steel pontoons, recently launched, are to be used by the U. S. Engineer Department for supporting suction dredge pipe in connection with dredging operations in the Mississippi River. Each pontoon weighs 23,000 lb. and is 28 ft. in diameter at the water's edge and 5½ ft. in depth. A recessed trough is built across the deck of the pontoons to accommodate a dredge pipe with a diameter of 36 in. The pontoons were manufactured for the government by the Stacey Companies, of Cincinnati.

mento division until 1918, when he was appointed chief engineer in charge of the Pacific Lines for the U. S. Railroad Administration. At the termination of federal control in 1920 he was appointed to his recent position as engineer, maintenance of way and structures, and was more recently put in charge of the railroad's valuation department.

Mr. Kirkbride is the sixth chief engineer in the history of the lines comprising the Pacific Lines of the Southern Pacific. Theodore D. Judah, who located the original line over the Sierra Nevada Mountains for the western link of the first transcontinental railroad, was the first chief engineer of the old Central Pacific Co., parent organization of the present Southern Pacific. Mr. Judah died in 1863, shortly after construction of the road was started. Chief engineers who followed are: S. S. Montague, 1863-83 (Central Pacific); G. E. Gray, 1870-84 (Southern Pacific); William Hood, 1885-1921; George W. Boschke, 1921-32.

W. M. Jaekle has been appointed engineer, maintenance of way and structures, to succeed Mr. Kirkbride. Mr. Jaekle has been assistant engineer of maintenance.

New York to Vote on $30,000,000 Relief Bonds

Authorization of a state debt of $30,000,000 is given in a bill signed this week by Gov. Roosevelt, of New York, the money to be used for relief of unemployment. An issue of bonds to supply the money will be passed on by the voters at the election in November.

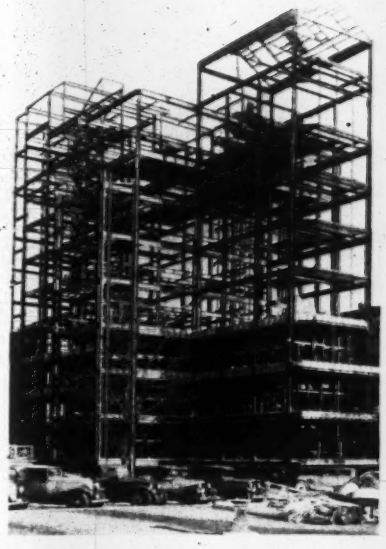
The governor also signed a bill appropriating $5,000,000, of which $500,000 shall be immediately available for direct grants for home and work relief, veteran relief and state improvements prior to June 1, 1932.

Tri-State Pollution Treaty Meets Opposition

Setting up a tri-state commission to take jurisdiction over pollution of harbor and coastal waters in the New York metropolitan district is meeting with strong opposition before the New Jersey legislature. The proposed Interstate Sanitation District would include parts of Connecticut, New York and New Jersey. Opposition before the New Jersey legislature comes from the state board of health on the ground that the proposed compact would transfer control over sanitary matters in about one-third of the state from the board of health to the commissioners of the projected sanitary district.

A companion bill to the one now before the New Jersey legislature recently was passed by the New York state legislature. It provides for the appointment of five commissioners and sets forth the substance of the compact to be entered into with New Jersey and with Connecticut. This bill was signed by Gov. Roosevelt on March 31. No bill has been introduced in Connecticut, as the legislature is not in session this year.

The bills presented to the New York and New Jersey legislatures were drafted by the tri-state treaty commission recently appointed to study harbor and coastal water pollution and to suggest needed legislation to the three states. The area to be included, classification of waters and forms of treatment required were laid down for the main committee by a subcommittee on research and engineering consisting of Frank S. Tainter, Thomas Parran, Jr., Charles A. Holmquist, James A. Newlands, William Schroeder and H. A. Foster.



NINE-STORY HOSPITAL FIRST ALL-WELDED BUILDING IN BOSTON

Noise elimination and an estimated saving of $2.50 per ton over bolted construction were the determining factors in deciding upon arc-welded construction for the new pediatric building for the Boston City Hospital. Although not as large as the fourteen-story field-welded building of the Edison Electric Illuminating Co. in Boston, the hospital building involves both shop and field welding for all joints, requiring 75,000 in. of ⅜-in. fillet welds on the 500 tons of steel. Windbracing connections were necessary because of the comparative narrowness of the hospital building. The building was fabricated and erected by the Palmer Steel Co., Springfield, Mass. J. Theodore Whitney, Boston, was welding consultant on the structure.

Washington Notes

By Paul Wooton
Washington Correspondent

WHILE the Senate steering committee has given the emergency road bill a place on the legislative program, several weeks will probably elapse before it is reached. The tax bill and the appropriation bills have the right of way and will consume the greater portion of the Senate's time for two or three weeks. The steering committee put the road bill in fourth place on its program. The bill proposing an investigation of the effects of depreciated foreign currencies on United States commerce, the bill dealing with additional naval construction and the resolution authorizing the President to reorganize the government departments are given preference over the road bill. An important bearing on the prospects of the road bill is the fact that the House made no provision in its tax bill for the $132,000,000 which the road bill would require.

Loans to Railroads

Controversy on the question whether the Reconstruction Finance Corp. should take up railroad bank loans probably will continue indefinitely unless the threat of legislation to prohibit further advances for this purpose is taken seriously. Having given its reluctant consent to a loan for paying off half the Missouri Pacific's short-term bank loans, the Interstate Commerce Commission has deferred action on the Baltimore & Ohio's application for advances to meet bank loans of $1,000,000 due April 20 and $8,000,000 due May 25, and gold notes for $35,000,000 maturing Aug. 10.

Washington reports that actually there is little chance for enactment of Senator Couzens' proposal to take the making of loans to railroads out of the hands of the Reconstruction Finance Corp. and give to the I.C.C. full control over administration of a revolving loan fund of $400,000,000 limited to payment of maturing bonds, debentures and equipment notes.

Publication by the Finance Corp. of its first quarterly report shows loans of $60,787,757 to sixteen roads and repayment of $1,147,952 understood to have come from the Railroad Credit Corporation in funds collected from freight surcharges. The R.F.C. has loaned approximately $17,000,000 against orders of the Credit Corp. pending accumulation of the surcharge fund. The first monthly report of the railroad agency shows loans of $2,363,200 actually made and $14,538,452 authorized, as of March 31.

Would Legalize Trade Agreements

Legislation that would give definite legal status to agreements on trade practices negotiated with the sanction of the Federal Trade Commission was indorsed by Charles F. Abbott, executive director of the American Institute of Steel Construction, March 31 as offering a means of eliminating the practice of peddling bids. Mr. Abbott told a subcommittee of the Senate judiciary committee that if agreements reached under the auspices of the trade commission are not open to attack under the anti-trust laws, as proposed in the Nye bill, subcontractors could get together and agree to outlaw this vicious practice. Mr. Abbott asserted that practically all subcontractors engaged in public building work are now subjected to pressure by "brokers" who obtain the general contract and have been forced to take subcontracts at prices 20 to 25 per cent below what the government was paying for the jobs. This has gone so far that there are only a few subcontractors and material supply concerns in the country that can afford to accept contracts on public works, he declared.

River and Harbor Work

An expedited waterway improvement program would be a material factor in relieving unemployment and in improving business conditions, a subcommittee of the Senate commerce committee was informed on April 4 by representatives of business and shipping interests from the Mississippi Valley. These witnesses appeared in support of a bill introduced by Senator Shipstead proposing a bond issue of $500,000,000 for the immediate completion of all river and harbor projects. The subcommittee is headed by Senator Nye, of North Dakota.

Louisiana Contractors Asked to Accept Bonds

Road and bridge contractors and machinery and material firms that hold certificates of indebtedness of the Louisiana highway commission will be given until April 11 to accept or reject a plan under which 80 per cent of their obligations will be paid in cash and the balance held as a credit under the recent sale of $15,000,000 of state highway bonds to the Pyramid Securities Co., New Orleans. The plan provides that those holding certificates shall receive 80 per cent in cash and 20 per cent in bonds. The bonds, however, must be deposited with the securities company to serve as collateral on the basis of which the cash is to be advanced.

Work Stops on Half-Completed Red River Bridge

One contractor, the List & Weatherly Construction Co., which is building the Shreveport-Bossier traffic bridge over Red River, has refused to accept the plan providing that payment be made by 80 per cent cash and 20 per cent in bonds. Work on the bridge, which is 50 per cent completed, has been stopped pending negotiations between the highway commission and the contractor.

Los Angeles Water Bonds Provide Work for 5,000 Men

Representing 31 per cent of the amount spent for construction from funds available from the Los Angeles, Calif., $38,800,000 water bonds of 1930, $1,660,000 has been spent by the department of water and power in the past eighteen months for labor, according to H. A. Van Norman, general manager of the department.

Total expenditures from the 1930 bond fund in the eighteen months were $11,400,000, of which $5,350,000 represents investments in construction and labor, and $6,050,000 was for purchase of privately owned water-bearing ranch and town property in the Owens Valley.

Work has been provided for 5,000 men on various projects of the water system since funds were made available from the water bonds. Construction work includes enlargement of the Chatsworth reservoir and lower San Fernando reservoir, enlargement of the capacity of the Owens Valley aqueduct and extensions and enlargements of street mains.

20-Mile Water Tunnel for New York Holed Through

The last section of Tunnel No. 2 of the Catskill aqueduct system, which supplies New York City with water, was holed through on March 30. The tunnel is 20.2 miles long and extends from Hill View reservoir, near the northern city line in Yonkers, south through the borough of the Bronx, under the East River to Queens and under Newtown Creek to Brooklyn, where it connects with the southerly end of city tunnel No. 1, the original Catskill aqueduct tunnel, thence south 1.3 miles to Hamilton Ave., Brooklyn. City tunnel No. 1 runs from Hill View reservoir through the Bronx, thence under Harlem River, down the center of Manhattan Island and under the East River to Brooklyn. It was completed in 1917.

The new tunnel is in rock at depths ranging from 200 to 760 ft. below the surface. It is to be concrete lined, with an internal diameter of 17 ft. to its connection with tunnel No. 1. Beyond that point the diameter is to be 15 ft. The estimated carrying capacity is 700 m.g.d. The present tunnel has a capacity of 500 m.g.d.

Contract for the terminal was let to Patrick McGovern, Inc., in October, 1928, at a total of $42,692,867. Subsequently the award was contested because it was about $15,000 above the combined bids for individual sections of the tunnel, but the award was upheld by the courts in March, 1929. When the contract was awarded it was expected that the work would take six years. It is now one year ahead of this schedule. A map showing the location of the tunnel was published in *Engineering News-Record*, Oct. 11, 1928, p. 562, at the time of the award of the contract.

Tonnage Declines on New York Canals

Tonnage on the Champlain barge canal, part of the New York state barge canal system, has decreased from 415,717 tons in 1928 to 218,178 tons in 1931. Traffic on the feeder canal serving Glens Falls and Fort Edward has declined to such an extent that Fred'k Stuart Greene, superintendent of public works, has recommended abandonment of the canal for navigation purposes, retaining it only to supply water to the summit level of the Champlain canal. Because of the decrease in traffic the operating force on the Champlain barge canal and the Glens Falls feeder is to be cut drastically in 1932.

Acme Photo

A SUBWAY IN MINIATURE

Models of New York City's underground railroads have been constructed for the board of transportation since 1908 by Arthur Weindorf. Shown above is a model of an underpinning job on one of the subway lines. Models of houses are made to allay the fear of taxpayers that their buildings might cave in if a subway were built beneath them.

Plans for a New San Diego Sewerage System Studied

Plans for a new sewerage and disposal system for San Diego, Calif., prepared under contract after a call for bids late in 1930 (*ENR*, Dec. 11, 1930, p. 942), have been completed and are now being studied by the city engineer. The bill of $18,000, the figure submitted by the one original bidder on the work, is before the city council and will await the city's review of the plans. The plans were filed by C. E. Frisbie, who took the assignment on original contract from F. W. Seifert after the validity of the contract had been attacked by the state board of registration because the latter was not a registered civil engineer.

At the time of award of contract early in 1931 (*ENR*, Jan. 15, 1931, p. 123; April 30, 1931, pp. 715 and 745) the case aroused considerable interest among California sections of the American Society of Civil Engineers and in spite of their protest the contract was awarded for the preparation of plans and specifications on the basis of the call for bids. The bid of $18,000 by Seifert was the only bid received. According to original agreement, the survey was to have been completed early in 1932, but a 45-day extension was granted and the plans and specifications were filed Feb. 15. The plans cover new sewer lines and collecting mains at an estimated cost of $2,300,000 and treatment and reclamation plants at an estimated cost of $2,300,000.

Reduced Cost of Paving Strikingly Illustrated

The reduced cost of paving construction today compared with the cost eleven years ago was strikingly brought out at a recent meeting of the city council of Buffalo, N. Y., when an old contract which had been slumbering for that length of time was dug out of the files. The contract was for paving of Forest Ave. and was at the rate of $7.25 a yard. Recently another bid was submitted for paving another part of the street, but the cost was only $3.73 a yard. The old contract was awarded but the work was never done, and now the council is seeking to have the contractor annul it and bring the price down to present-day levels.

Baltimore May Vote on $22,000,000 Public-Works Bonds

Plans to have a bond issue totaling $22,000,000 submitted to the voters of Baltimore at a primary election on May 2 are being made by Mayor Howard W. Jackson, who is seeking a legal ruling from the city and state law departments. The last session of the Maryland general assembly passed the enabling acts, but all the issues, with the exception of one for water supply, were kept off the ballot by the last municipal administration.

The bonds are $10,000,000 for schools, $5,000,000 for paving and bridges, $5,000,000 for sewers, $1,500,000 for electrical conduits and $500,000 for a new court building. If the bonds are approved by the voters, it is planned to spend none of the money until next year and then only as needed.

Toll Schedules Reduced on Staten Island Bridges

Lower toll schedules on the three bridges between Staten Island and New Jersey have been announced by the Port of New York Authority, partly in anticipation of the traffic that is expected during the late spring and summer months, which it is felt would be stimulated through the adoption of the new charges. A combination toll rate was also placed in effect whereby a passenger car may use the Bayonne bridge and the Holland tunnel at a flat rate of 75c. The spans affected are the Bayonne bridge, over the Kill van Kull between Bayonne, N. J., and Port Richmond, S. I.; the Goethals bridge, between Elizabeth, N. J., and Howland Hook, S. I.; the Outerbridge Crossing, between Perth Amboy, N. J., and Tottenville, S. I. Regular patrons are given consideration in the revised schedule by means of a commutation ticket which provides a lower toll on the structures than that over the ferries. Motor trucks, as well as passenger cars, receive the benefit of the lower rates.

Brief News

RAIL LENGTHS of 197 ft. are being tried on the German federal railway. They are formed of two 98½-ft. lengths welded together, to reduce joint trouble.

A BILL which would have required all counties with 20,000 or more inhabitants to employ a county surveyor at a salary of $5,000 a year has been killed by the Kentucky general assembly.

A FIVE-YEAR PUBLIC WORKS PROGRAM has been started in the Kingdom of Iraq which will include, among other projects, the construction of roads and dwellings in the city of Bagdad and a steel bridge over the Tigris River.

A BILL amending the highway law in New York State has been signed by Gov. Roosevelt, permitting the superintendent of public works to require contractors to make affidavits that all laborers have been paid for services before certificates approving partial or final payments on contracts are made.

THE LAST STEEL GIRDER has been dropped into position on the new $3,000,000 Burrard Bridge at Vancouver, B. C. Riveting is expected to be completed within a few days, and concrete decks are being laid over the steel at the south end. The viaduct will probably be opened for traffic during the coming summer.

RECOMMENDATION that engineering studies be undertaken at once with respect to certain closely related phases of the bureau of power and light and the water department of the city of Los Angeles, Calif., has been made to the board of water and power commissioners by the accounting concern of Lybrand, Ross Bros. & Montgomery. Informal charges have been made in the past that the bureau of power and light's financial reports have been given a favorable showing at the expense of the water department, particularly in connection with the use by the bureau of power and light of falling water of the water department's Owens Valley aqueduct system.

Personal Notes

J. C. HAMILTON, for many years city clerk and temporary city manager, has been named city manager of Port Arthur, Tex.

JOHN W. BAUMGARTNER, civil engineer, appointed March 10 to the board of water and power commissioners of Los Angeles, Calif., has been elected president of the board.

HENRI DEFRAITES, formerly a building contractor in New Orleans, has been appointed superintendent of the city's building department, succeeding Walter Van Hoven, who held the position for seven years.

PAUL E. DUFOUR, until April 1 valuation engineer of the California state railroad commission, has been retained by the commission as assistant engineer and has been assigned to the general staff.

FRANK C. ROE, of Chicago, has been engaged by the Carborundum Co., of Niagara Falls, N. Y., as sanitary engineer. His duties will be to assist in research and promotion of sales of diffuser plates used in connection with aeration of sewage.

FRANCISCO GOMEZ-PEREZ, who has been designer for the National Highway Commission of the government of Mexico, is now resident engineer at Rodríguez Dam, Lower California. He was principal assistant to the consulting engineer on the construction of the dam from May, 1929, to April, 1930.

Obituary

BENJAMIN C. ADKINS, former water commissioner of St. Louis, Mo., died on April 1 in Dallas, Tex., as the result of gas asphyxiation. The coroner rendered a verdict of suicide. Mr. Adkins was graduated from Washington University in 1886 and soon afterward went with the St. Louis water department as assistant civil engineer. He rose gradually in the department until in 1903 he was appointed water commissioner. He resigned in 1911. During his connection with the department he superintended the work of construction of the waterworks at the Chain of Rocks. Mr. Adkins, who was 68 years old, was a member of the American Water Works Association, of which he was president in 1905-06. He went to Dallas about fifteen years ago as local representative of the J. W. Thompson Contracting Co. He aided in construction of the Union Terminal and several other Dallas buildings. He retired from active business about a year ago because of ill health.

L. L. BEALL, chief engineer of the Atlanta, Birmingham & Coast R.R., died at his home in Atlanta, Ga., on March 22, following a heart attack. He was 66 years old. Mr. Beall, who was a graduate of Lafayette College, was location engineer for the Seaboard Air Line R.R. prior to becoming chief engineer of the A.B.&C. He had also been connected with the Georgia Railroad, the Atlanta & West Point, the Charleston & Western Carolina, the Georgia, Southern & Florida, and the St. Louis & San Francisco.

JAMES A. BEATTY, contractor, of Toronto, was found dead on March 28 underneath his stalled automobile, a victim of monoxide gas poisoning. Mr. Beatty, who was 52 years old, was a partner in the contracting firm of Morrow & Beatty, which supervised the erection of the Abitibi and Iroquois Falls power plants and at present is completing a power dam at Chats Falls, on the Ottawa River.

EMERSON H. STEWART, of Elmira, N. Y., a state highway engineer, who had supervised construtcion work in Elmira, Binghamton, Hornell, Poughkeepsie and elsewhere, died on April 1 after inhaling fumes from the exhaust of his car in his garage. Mr. Stewart was a graduate of the University of Rochester and had been with the highway department 25 years.

JAMES R. GREENE, formerly head of the engineering department of the Pittsburgh-Des Moines Steel Co., of Pittsburgh, Pa., took his life by hanging at Penn Yan, N. Y., on April 1. Three months ago Mr. Greene was forced to stop work owing to a mental breakdown. He was a graduate of the University of Michigan in the civil engineering school.

PAUL BERTRAM SPENCER, engineer of structures for the New York, New Haven & Hartford R.R., died on March 26 at his residence in New Haven, Conn. Mr. Spencer was born in 1881 in Boston and entered railroad service with the New York, Ontario & Western R.R. in 1902. He went to the New Haven road in 1905 and remained continuously in its service until his death, with the exception of about a year when he was engaged in railroad construction work in Florida on the Charlotte Harbor & Northern Ry. He was appointed engineer of structures of the New Haven in 1920. Mr. Spencer was associated with practically all major construction improvements on the railroad since entering the service, including the six-tracking of the Harlem River branch, repair facilities for electrical equipment at New York, rebuilding of the Connecticut River bridge at Hartford, and construction of the new Thames River bridge at New London. He was a member of the American Society of Civil Engineers, the Connecticut Society of Civil Engineers and the American Railway Engineering Association.

SOCIETY CALENDAR

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Atlantic City, June 20-24.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Yellowstone National Park, July 9.

AMERICAN WATER WORKS ASSOCIATION, annual convention, Memphis, Tenn., May 2-6.

AMERICAN WELDING SOCIETY, annual meeting, New York City, April 27-29.

NEW ENGLAND SEWAGE WORKS ASSOCIATION, annual meeting, Boston, April 25.

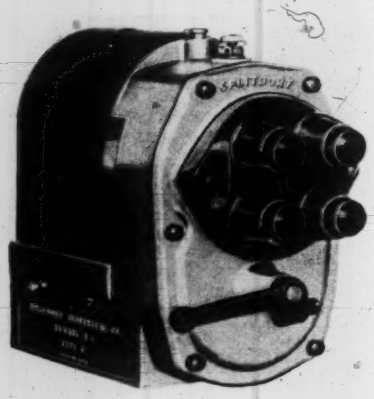
SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, 40th annual meeting, Oregon State College, Corvallis, June 29-July 1.

COLORADO ENGINEERING COUNCIL has awarded its 1932 medal to Lewis M. Stimson, Greeley, Colo., for outstanding scholastic achievement in engineering during his senior year at Colorado Agricultural College.

Construction Equipment and Materials

Inductor-Type Magneto

A new all-inclosed inductor-type magneto adapted to all types of engines up to and including six cylinders has been developed by the Splitdorf Electrical Co., Newark, N. J. The new line, known as

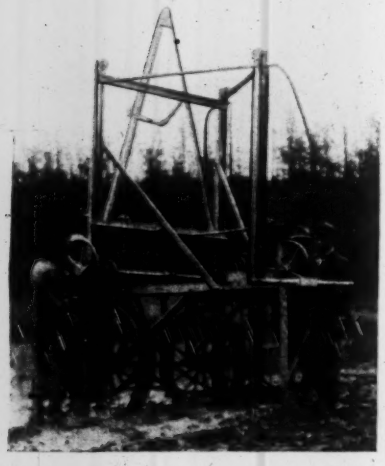


Splitdorf Type C magneto.

Type C, has interchangeable features to permit quick change-over of assemblies to meet the requirements of the engine manufacturer. Impulse starters may be assembled, removed or exchanged without disturbing any part of the machine. It is adjustable for either direction of rotation. The housing is a unit die-casting, forming a dustproof and waterproof inclosure. Electrically the magneto is adequate for all types of engines used for trucks and roadbuilding and construction machinery.

Rig Handles Pipes and Hose for Jetting Fills

A two-wheeled rig carrying three 1-in. jet pipes for jetting highway fills has been introduced by the C.H.&E. Mfg. Co.,

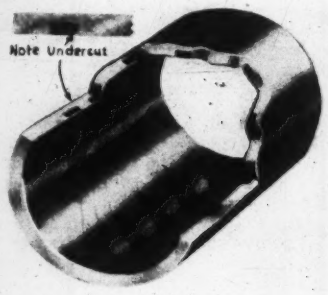


Jetting fill on Illinois highway with C.H.&E. Fil-Jetter.

Inc., 120 East Mineral St., Milwaukee, Wis. The unit is known as the C.H.&E. Fil-Jetter. The jets, spaced 5 ft. c. to c., have a maximum working depth of 8½ ft., but extra lengths of pipe may be attached if greater depth is desired. Hand wheels and a cable and pulley arrangement raise and lower the jets. The jets, working under water pressures of 40 to 60 lb., are equipped with removable hardened steel nozzles which have one hole in the end and four on the sides. Quick-operating gate valves are provided on the header for each jet. The outfit is mounted on two 42-in. roller-bearing steel wheels. A steel pole is provided for trailing. The complete rig weighs 990 lb. The manufacturer is now building one of aluminum structural parts, which will greatly decrease the total weight.

Spiral-Type Oilless Bearing

A new type of oilless bearing, called the spiral type, has been perfected by E. A. Williams & Son, Inc., 111 Plymouth St., Jersey City, N. J. It is designed particularly for sliding, oscillating, vertical, horizontal motion and full revolution speeds up to 2,500 r.p.m., depending on load; sub-



New Williams oilless bearing.

ject to heat up to 400 deg. The grooves on the spiral-type bearing are machined with an undercut, which assures retention of graphite. The grooves are arranged to provide thorough lubrication with sacrifice of a minimum amount of bearing surface.

New Equipment in Brief

Aluminum Paint—A new type of aluminum paint known as "Permite Resalum," manufactured by the Aluminum Industries, Inc., Cincinnati, Ohio, is claimed to have unusual spreading qualities and resistance to corrosion and weather. The paint is prepared in ready-mixed form, ready for immediate application.

Portable Generating Unit—Baldwin-Southwark Corp., Philadelphia, Pa., is now manufacturing large-capacity portable generator units mounted on standard-gage railroad cars. Plants of several sizes have been designed, the units ranging from 2 to 800 hp. The larger units are equipped with two eight-cylinder oil engines. The chassis upon which the unit is mounted is equipped with standard couplings and braking equipment permitting it to be handled in a regular freight train. The plants are equipped complete with switchboard, radiator cooling system, mufflers, centrifuges and other accessories ready for service.

High Lift Loader—The Moon Tractor Co., McCormick Building, Chicago, announces the "Fabriform" loader for tractor attachment. A ½-yd. bucket with a capacity of 1,000 lb. operating on a vertical frame mounted on the front of the tractor has a loading height of 8½ ft. It is designed especially for handling bulk material at low cost. Power is supplied by a take-off from the tractor engine.

Screening and Washing Equipment—Allis-Chalmers Mfg. Co., Milwaukee, Wis., has made a number of improvements to its centrifugal vibrating screen. Also screens having one, two or three decks have been developed in the 4x10, 5x10- and 5x12-ft. sizes. To meet the increasing demand for stone- and gravel-washing equipment, the company has redesigned and improved its screw and log washers.

Heavy-Duty Trucks—Two new six-cylinder motor trucks, each with a rated capacity of 5 tons, have just been announced by the International Harvester Co., Chicago. These new models are available in wheelbases of 160, 180, 200 and 225 in. Engines are of the six-cylinder valve-in-head type. Trucks are equipped with power take-off openings on each side of the transmission case. Four semi-elliptic springs are provided at the rear end, instead of the usual two springs.

Business Notes

WHITE MANUFACTURING CO., Elkhart, Ind., announces that it has taken over the business of the Chausse Oil Burner Co., of Elkhart. Development of a complete new line of bituminous roadbuilding machinery by the White Mfg. Co., engineers influences the decision to market this equipment hereafter as Chausse-White products. These consist of bituminous paving mixers for both hot and cold laying, rotating aggregate driers and complete premixing plants, in addition to the Chausse street repair machines, tar kettles and kerosene torches.

DOUGLAS FIR PLYWOOD MANUFACTURERS, Skinner Building, Seattle, Wash., announces prizes totaling $1,500 to be paid for the best architectural design using Douglas fir plywood as a basic material for building or home interiors. Another plan sets aside $5,000 for the purchase at $25 each of sketches showing practical uses of Douglas fir plywood for home or office construction and modernizing, cabinet-making or industrial products, and elementary and advanced manual training projects. Full details may be secured by writing the association.

BEAUMONT BIN CO., 319 Arch St., Philadelphia, has been organized from the former bin division of the Beaumont Mfg. Co. The company will devote itself entirely to specializing in the design and manufacture of all types of bins, including storage and aggregate bins, central mixing plants, bulk cement handling, automatic weigh batchers and all types of bin gates. A new bulletin showing the equipment offered is ready for distribution.

R. FUESS, INC., of Berlin, Germany, has established a New York office at 245 West 55th St. The company manufactures instruments for scientific research and industrial control, including instruments for measuring air pressure, temperature and humidity, wind, rainfall, evaporation, radiation and sight. It also produces several types of microscopes, thermal control instruments and spectroscopic apparatus.

Business Side of Construction

Drastic, Widespread Wage Cutting in All Sections

SKILLED wages in twenty cities averaged $0.935 per hour on April 1, compared with $1.08 one month ago, a drop of 13 per cent. A year ago the average was $1.36. Average common labor rate is 41.22c. per hour, compared with 43.58c. last month, a drop of 5 per cent. The hourly wage a year ago was 53.59c. Rates in the manufacturing industries average 59.2c. for skilled and 42.6c. for unskilled.

As indicated by these drops in average rates, the wage structure continues to crumble throughout the country. This is of course the season for scale revision, but not in many years have there been such universal and drastic slashes in both the scale and the actual wage. Reductions are reported this month in twelve of the twenty cities covered monthly by *Engineering News-Record*. The situation is clearly portrayed by the accompanying news from 29 cities in seventeen states.

New Britain—Carpenters' union accepts cut of 16½c. per hour, to 90c., from April 1.

Boston—Painters' union accepts wage cut of 20c. per hour, to $1.17½, until April 1, 1933. State emergency committee on unemployment disbanded April 1, leaving situation to local employment relief board.

Rochester—Carpenters' union accepts wage reduction of 20 per cent, to $1 per hour, until Dec. 31. Painters are negotiating for a lower rate. Monroe County effects reduction of 15c. per hour, to 25c., for public relief work.

New York—Forces of emergency workers on public improvement projects will be reduced 3.5 per cent, to 34,966 men, during April, and work schedules will be changed from three days to two days a week.

Long Island—Open-shop principle adopted

(Continued on page 526)

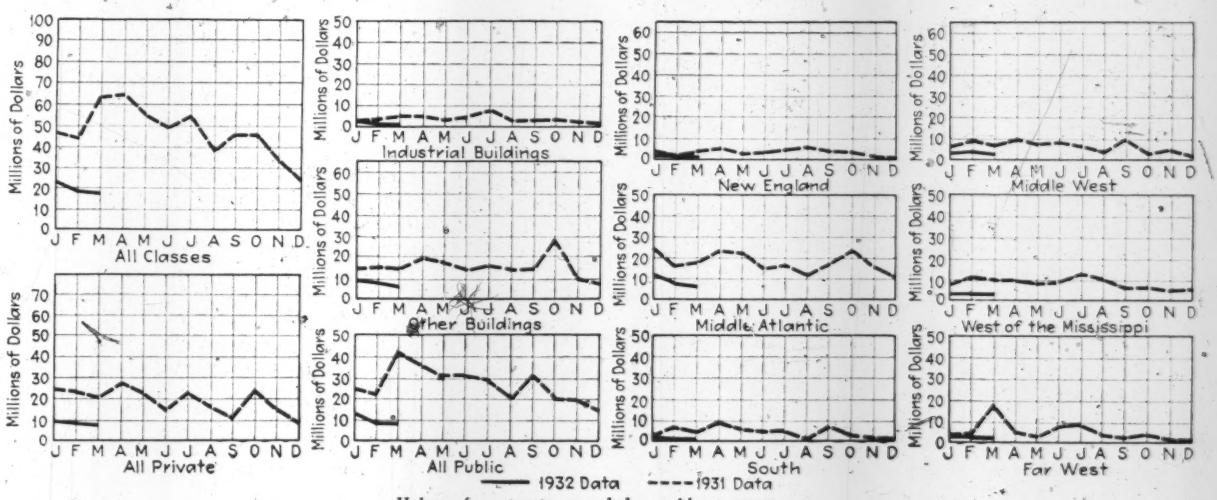
Volume of Public and Private Work Lowest Since 1921

First quarter contracts total 254 millions, against 663 millions in 1931 and 826 millions in 1930. The drop of 62 per cent from a year ago was quite evenly distributed, both geographically and by classes of construction. It varies from 45 per cent in New England to 76 per cent in the South, is 68 per cent in the Far West and 60 per cent in the Middle Atlantic, Middle West and the region between the Mississippi and the Rockies. The drop is 63 per cent in public construction and 60 per cent in private engineering construction.

Though the decrease is about the same for both public and private, it is from a record high volume of public work and from the lowest volume of private work recorded in many years. Until 1931 private construction, consisting of buildings, public utility construction and private engineering structures, amounted to about two-thirds of heavy construction. In the first quarter of 1930 this factor was 64 per cent; in 1931 it dropped to 44 per cent due to an identical decrease in private work and a 24 per cent increase in public. It is now 46 per cent.

ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN MARCH, 1932
(Thousands of Dollars (000 Omitted))

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States March 1932	United States Three Months 1932	United States Three Months 1931	Canada March 1932
Waterworks	$228	$164	$112	$415	$505	$947	$1,571	$4,512	$11,083	$391
Sewers	167	581	211	268	328	236	1,791	7,040	19,422	293
Bridges, public	168	508	370	1,110	1,119	305	3,580	9,763	23,657	
Excavations	25	62		30	397	119	633	1,181	5,798	
Streets and roads	782	564	1,069	2,532	6,982	4,255	16,184	37,927	129,690	340
Federal government	369	2,590	1,600	4,671	2,954	932	13,116	37,736	91,372	
Unclassified, public	320	945	74	247	192	2,248	4,026	10,086	32,014	574
Buildings, public	1,490	4,694	200	452	1,335		8,171	29,092	56,264	1,083
Total public	3,549	10,108	3,636	9,725	13,812	8,242	49,072	137,337	369,297	2,681
Buildings, industrial	1,825	4,210	680	1,032	1,380	180	9,307	24,502	44,820	224
Buildings, commercial	2,400	14,095	150	1,075	675	1,150	19,545	73,396	150,876	1,475
Buildings, private				50	140		190	890	255	
Unclassified, private	85	1,802	24	425	2,169	3,500	8,005	17,509	97,835	150
Total private	4,310	20,107	854	2,582	4,364	4,830	37,047	116,297	293,786	1,849
March, 1932, 5 weeks	**7,859**	**30,215**	**4,490**	**12,307**	**18,176**	**13,072**	**86,119**			**4,530**
February, 1932, 4 weeks	6,074	27,922	3,562	15,626	12,644	10,818	76,646			1,962
March, 1931, 4 weeks	16,518	72,373	19,220	29,564	39,745	69,926	247,346			9,688
Three months, 1932	20,015	101,328	13,552	40,776	43,099	34,864		253,634		15,919
Three months, 1931	35,549	250,597	59,004	99,300	110,560	108,073			653,083	33,469



Value of contracts awarded—weekly averages.

Widespread Wage Cutting

(Continued from page 525)

April 1 by building trades employers throughout Long Island, except Brooklyn and Queens. All major wage contracts have expired. Carpenters' scale reduced 65c. per hour, to $1; bricklayers' and plasterers,' 67½c., to $1.25.

Trenton—Retrenchment in state road work because of depleted funds may necessitate the changing over of 2,000 emergency laborers to direct relief after June 1.

Plainfield—Bricklayers', masons' and pasterers' unions voted March 22 to reduce scale 22½c. per hour, to $1.70.

Elizabeth—Bricklayers sign agreement to reduce scale 25c. per hour, to $1.68¾, while carpenters sign for cut of 14c., to $1.40, April 1. A 12 per cent reduction has been voted by sheet-metal workers' union.

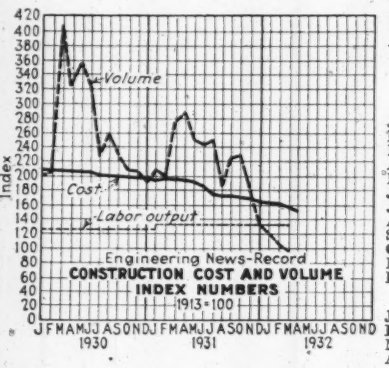
Pittsburgh—Painters agree on reduction of 22½c. per hour, to $1.27½, affecting 1,500 union members. Employers hold out for $1.12½. Allegheny County's move to abandon public work relief will release $300,000 to be used in direct relief, but it will strand 10,000 men who were to have received emergency employment, municipalities furnishing the materials. At least 6,800 men will retain jobs paid from $500,000 appropriation granted some time ago by county commission.

Baltimore—Plasterers', cement finishers' and lathers' unions accept reduction of 50c. per hour, to $1.25. On March 15 municipal free employment service separated from city government control, though maintenance fund will continue to come from board of estimates. Court of appeals decides that wage schedules fixed by this board or by other city officials do not bind contractors bidding for public or other work.

Washington—Special wage scale proposed on local Mission building project to range from 28½c. for common labor to 70c. per hour for skilled workers. This schedule is approximately half that of the prevailing union wage scale and is so arranged as to distribute relief work among a larger number of unemployed men. District committee on employment has skeletonized organization in readiness for next autumn.

Construction Cost and Volume Index Numbers

The April Cost Index (153.12) is 2.5 per cent under that for March and is 20.3 per cent below that of April, 1931. Not since December, 1916 (149.41), has the Cost Index touched so low a level. The March Volume Index (97) is 7.6 per cent smaller than that for February and 65.1 per cent smaller than that for March, 1931. The March volume is the smallest for any month since February, 1922, at which time the Volume Index touched 68.


Index
Volume
Cost
Labor output
Engineering News-Record
CONSTRUCTION COST AND VOLUME INDEX NUMBERS
1913=100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1930
1931
1932

E.N.-R. Cost		E.N.-R. Volume	
April, 1932	**153.12**	**March, 1932**	97
March, 1932	157.24	Feb., 1932	105
April, 1931	191.63	March, 1931	278
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.85	1930 (Average)	260
1913 average	100.00		
1931		1931	
January	194.48	January	208
February	196.61	February	198
March	194.51	March	278
April	191.63	April	289
May	189.33	May	251
June	187.23	June	243
July	174.37	July	248
August	171.38	August	187
September	171.40	September	225
October	169.78	October	229
November	169.28	November	180
December	166.23	December	133
1932		1932	
January	162.48	January	121
February	161.82	February	105
March	157.24	March	97
April	153.12		

Frankfort (Ky.)—In the event that the city is unable to sell an issue of sewer bonds, 1,000 laborers will be dismissed. Legislative moves are being made to increase the interest rate, from 4½ to 5.38 per cent.

Memphis—Carpenters' union voluntarily reduces scale 12½c. per hour, to 87½c., to compete with non-union men receiving 75@80c. per hour on local waterworks project.

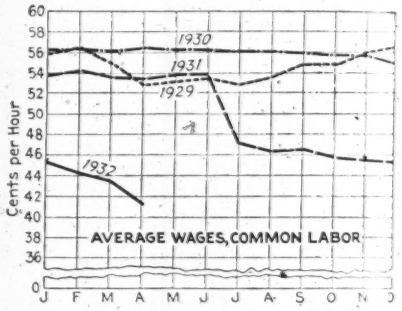
Cincinnati—Minimum common labor rate of 45c. per hour declared by director of public works to apply on all city projects.

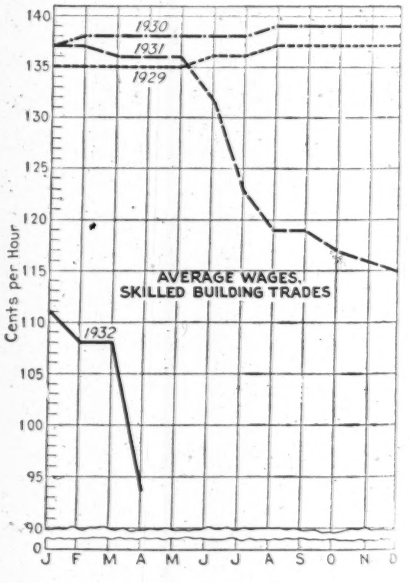
Cleveland—Ironworkers accept reduction of 25c. per hour, to $1.25, in official scale. Actual wages, however, are 90c. to $1.

Columbus—Plasterers' union voted March 5 to accept a reduction of 37½c. per hour, to $1, the 1918 level, locally. Rule also adopted that no union plasterer can work more than eight hours a day.

Toledo—Plumbers and steamfitters agree on wage reduction of 25c. per hour, to $1, for either trade.

Youngstown—Negotiations are under way to reduce building wage scale as follows: Bricklayers, 40c. per hour, to $1.10;





CURRENT BUILDING AND CONSTRUCTION TRADES WAGE RATES PER HOUR

Advances since last month are indicated by **heavy type,** declines by *italics*

Cities	Bricklayers	Carpenters	Hoisting Engineers	Pile Drivers	Structural Iron Workers	Masons' Laborers	Common Laborers
Atlanta	$0.60	$0.40	$0.50	.....	$0.50	$0.25@.50	*$0.10@.30*
Baltimore	1.25	.80@.90	1.00@*1.25*	$0.65	1.00@1.25	.65	.30
Birmingham	.75@.87½	.60	.75	.....	.75	.30@.40	.15@.25
Boston	*1.00*	*1.00*	*1.00*	1.27½	*1.00*	.85	.40@.80
Cincinnati	.90	.50	1.00	1.00	1.00	.70	.25@.45
Chicago	1.36	1.30	1.30	1.30	1.34	.78	.50@.78
Cleveland	.90	.87½	.90@1.00	1.10	.90@1.00	.50@.62½	.30@.40
Dallas	1.00	.75	.75@1.00	.75@1.00	.75@1.00	.35@.50	.20@.25
Denver	1.00@1.12½	.75@.87½	.75@.87½	.....	.75@.87½	.50	.31½@.50
Detroit	1.00	.70	1.00	1.00@1.10	1.00	.50	.30@.50
Kansas City	*1.30*	*1.12½*	*1.12½*	*1.06*	*1.12½*	.80	.25@.70
Los Angeles	.62½	.50	.75	.75	.75	.50	.40
Minneapolis	1.10	.75	.80	.....	.90	.70	.45
New Orleans	.60@.80	.40@.56	.80@1.12½	.90	.80@1.12½	.50	.15@.20
New York	1.50	1.25	1.92½	1.78¾	1.92½	.81½	.50@.81½
Philadelphia	1.50	.80	1.02½@1.36	1.00	*1.02½*@1.37½	.40	*.30*@.40
Pittsburgh	*.60*	*.60*	*.60*	.....	*.60*	.50	*.40*
St. Louis	*1.17½*	*1.00*	*1.17½*	*.85*	*1.17½*	*.80*	.35@.70
San Francisco	1.37½	1.12½	1.12½	1.12½	1.37½	.87½	.40@.68¾
Seattle	*.75*	*.50*	1.12½@1.25	1.12½@1.25	1.12½@1.25	.70	.40@.70
Average	*1.00*	*.78*	*1.01*	*1.05¾*	*1.02½*	*.58*	*.4122*
Montreal	1.12½	.75	.70	.70	.75	.40	.25@.40

carpenters and hoisting engineers, 32½c., to 92½c.; structural ironworkers, 50c., to $1; masons' laborers, 15c., to 70c.; common laborers, 10c., to 40c.

Chicago—Four trades have not yet signed agreements accepting 20 per cent wage reduction effective March 11: the electrical workers, mantel, marble and tile setters and terrazo mechanics.

Rock Island (Ill.)—Minimum common labor rate of 40c. per hour adopted by county road board. Hand labor will be substituted for steam shovels, tractors and other machinery.

Christopher (Ill.)—Concrete workers and masons' laborers approve reduction of 15 per cent in scale.

Minneapolis—Plumbers and steamfitters on strike over wage cut of 22½c. per hour, to 90c. Union contends that agreement does not expire until June 1 and that $1.12½ should have held to that date.

Davenport—Bricklayers represent the first local craft officially to accept recently proposed wage reduction of 25c. per hour, to $1.25, until May 1, 1933. Unemployment relief fund now exhausted after having provided for employment of 3,000 men since October, 1931.

St. Louis—Temporary wage reduction of 33⅓ per cent, proposed by contractors' organization, rejected by unions. Negotiations under way for possible revision to take effect May 1.

Kansas City—Unions sign agreement whereby wages of all crafts are reduced approximately 20 per cent for one year. New scale ranges from 50c. per hour for wreckers to $1.32½ for plasterers.

Denver—Contractors on Park Hill sewer project must pay a minimum wage of 62½c. per hour for common laborers, regardless of stagger system or other methods adopted to spread work.

Salt Lake City—Electricians' union accepts cut of 12½c. per hour, to $1, for 1932. House wiring, as a special provision, will carry rates 20 per cent lower than the new scale.

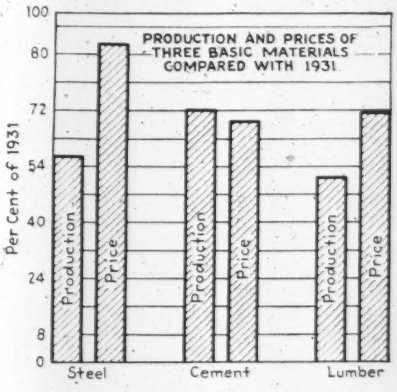
Sacramento—Twenty-six building unions accept wage cuts averaging 15 per cent.

Portland (Ore.)—Lane County highway commissioners reduce wage rate of road laborers 5c., to 20c.

Materials Notes

Steel—The Steel Corporation's backlog on March 10 was the lowest on record. The mill operating rate has dropped to 22 per cent of capacity, the lowest since the identical level on Jan. 9, 1932. A year ago the rate was 56 per cent, and in 1930 it was 73 per cent for the entire industry. The weekly rate of fabricated structural shipments was 10,500 tons in March, compared with 21,600 tons last year, a decrease of 51 per cent. Wire mesh, however, is moving in moderate volume. Effective May 2, steel shipped eastward from Pittsburgh will carry a reduced freight rate on less-than-carload lots only. For example, the less-carlot rate to New York, which is now 52c. per 100 lb., will be 41½c. The carlot rate of 35c. remains the same. While the mill base for billet-steel bars is quoted $1.50, imported bars sell at $1.10, the same price as the normally lower rail-steel bars.

Cement—The shipment rate of cement last month was 3,100,000 bbl., compared with 5,000,000 a year ago, a drop of 0.38 per cent. Production was 3,900,000 bbl., compared with 5,900,000 a year ago. Delayed seasonal increase shipments or orders have caused a slight increase in stocks. In the accompanying chart are shown production and prices of three basic materials, as percentages of their 1931 values.



MOVEMENT OF BASIC MATERIALS
(Two Months, January and February)

	1932	1931	Per Cent Change in 1932
Fabricated Structural Steel:			
Bookings, tons	110,800	316,800	—65.2
Shipments, tons	144,000	323,600	—55.5
Unfilled Steel Tonnage:			
On books of Steel Corp., end of Feb	2,545,629	3,965,194	—35.9
Steel Ingots:			
Production, tons	2,920,837	4,961,055	—41.3
Steel Castings:			
New orders, tons	34,359	87,130	—60.6
Production, tons	37,215	95,842	—61.2
Fabricated Steel Plate:			
New orders, tons	35,368	51,956	—32.0
Range Boilers:			
Production, No.	69,858	111,239	—37.8
New orders, No.	76,875	114,907	—33.3
Steel Boilers:			
New orders, No.	486	1,046	—53.6
Pig Iron:			
Production, tons	1,931,987	3,426,635	—43.5
Cement:			
Production, bbl.	8,997,000	12,515,000	—28.1
Shipments, bbl.	6,511,000	9,766,000	—33.3
Stocks, bbl.	26,631,000	28,612,000	— 7.0
Lumber (Softwoods):			
Production, M ft.	676,555	1,251,803	—46.0
Shipments, M ft.	971,355	1,498,812	—35.2
New orders, M ft.	985,095	1,517,957	—35.1
Unfilled orders, M ft.	444,035	672,191	—33.9
Stocks, M ft.	3,821,615	4,602,230	—16.9
Paint, Varnish and Lacquer:			
Sales, dollar value*	16,091,518	20,320,505	—21.2
Porcelain Plumbing Fixtures:			
Shipments, No.	4,582	8,296	—44.8
New orders, No.	3,501	10,129	—65.5
Unfilled orders, No.	3,548	30,526	—88.2
Stocks, No.	16,328	30,004	—45.6
Prepared Roofing:			
Shipments, squares*	1,773,715	1,394,625	+27.3
Terra Cotta:			
New orders, tons	3,733	6,457	—42.1
Vitreous China Plumbing Fixtures:			
New orders, No.*	76,149,000	250,183	—69.6
Shipments, No.*	172,229	172,334	—34.9
Unfilled orders, No.*	156,753	337,158	—53.7
Stocks, No.*	524,131	594,886	—11.8

*Figures for one month, January.

Lumber—No increase in consumption is expected by the manufacturers during the first half of 1932. Stocks are 3,746,000,000 ft., compared with 4,590,000,000 in 1931, a decrease of 18 per cent. Cumulative shipments this year total 1,339,000,000 ft., against production of 944,043,000 ft. The average West Coast mill quotation is $10.40 per 1,000 ft., unchanged since November, 1931. Consumer prices of pine, fir and hemlock dropped $2.75 to $7 in the Middle West.

Brick—Common "inside" varieties of brick have declined in price $1 per 1,000 to $8.50, delivered in Los Angeles and $12.50 at Birmingham. Open weather has facilitated shipments from the Hudson River stocks, although the plants have remained closed. Ohio plants are starting operations after protracted fall and winter shutdowns.

Asphalt—Bulk paving grades of asphalt are down 90c. per ton, to $13.70 f.o.b. St. Louis, and $1.80, to $16.30, Minneapolis.

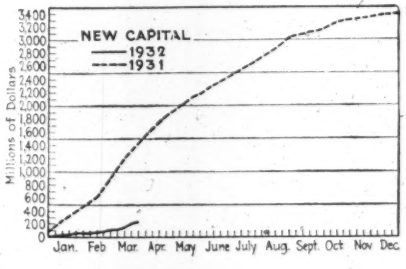
Capital and Contracts

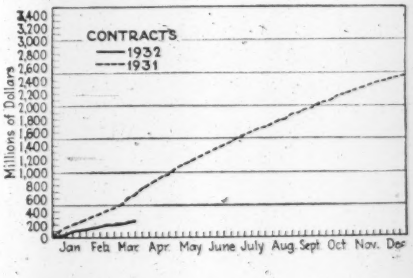
Public bond issues to the value of $18,000,000 were floated in the week ended April 2, 1932. In that week, however, no private new capital made its appearance in the market. In the week of March 26 public issues totaled $12,000,000, while private financing reached $20,000,000. The average for April, 1931, was $111,000,000—$52,000,000 public and $59,000,000 private. Cumulatively, the total for Jan. 1-April 2, inclusive, is $231,000,000, as compared with $1,317,000,000 in the corresponding period of 1931.

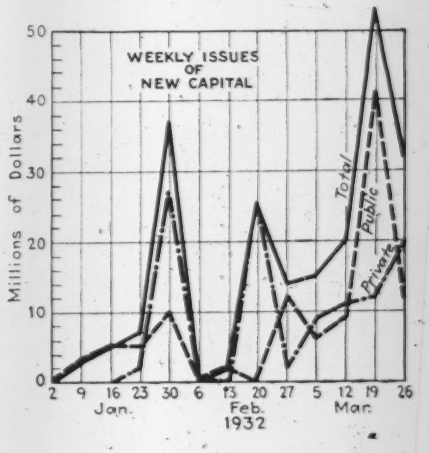
This week's contracts, with comparisons:

(In Thousands of Dollars)

Engineering Construction	Week of April 7, 1932	Average Week March, 1932	Average Week April, 1931
Federal government	$3,608	$3,002	$5,277
State and municipal	8,447	7,264	29,937
Total public	$12,055	$10,266	$35,215
Total private	4,522	6,944	28,166
Grand total	$16,607	$17,211	$63,381
Cumulative, all classes, Jan. 1 to April 7:			
1932			$270,177
1931			744,070







Current Prices of Construction Materials

Price advances since last month are indicated by **heavy type**; declines by *italics*

Building Materials

PORTLAND CEMENT—Prices are for carloads of 132 barrels or over, delivered to contractor at site of job. For cement in returnable cloth bags add 40c. per bbl.; in non-returnable paper bags add 15c. per bbl., to following net prices:

	April 7, 1932	One Mo. Ago	One Yr. Ago
Atlanta	$1.95	$1.95	$2.60
Baltimore	1.87	1.87	2.60
Birmingham	*1.93*	1.95	2.40
Boston	1.86	1.86	2.30
Chicago	1.55	1.55	2.10
Cincinnati	1.64	1.60	2.26
Cleveland	1.25	1.25	1.80
Dallas	1.88	1.88	2.15
Denver	1.95	1.95	2.20
Detroit	1.85	1.85	2.05
Jersey City	1.79	1.79	2.19
Kansas City	1.90	1.90	2.50
Los Angeles	1.95	1.95	1.92
Minneapolis	1.95	1.95	2.55
Montreal	1.95	1.95	2.20
New Orleans	1.90	1.90	2.35
New York	*1.69*	1.60	2.10
Philadelphia	1.95	1.95	2.25
Pittsburgh	1.78	1.78	2.50
St. Louis	1.85	1.85	2.15
San Francisco	1.95	1.95	2.64
Seattle	1.95	1.95	2.25

Current mill-prices per barrel to dealers, for carloads of 132 barrels or over, without including charge for four bags, f.o.b. Bag charges same as in preceding table:

Alpena, Mich	$1.20	Mason City, Ia	$1.10
Buffington, Ind	1.10	Norfolk, Va	1.61
Dallas, Tex	1.74	Northampton, Pa	1.21
Hannibal, Mo	1.10	North Birmingham, Ala	1.31
Hudson, N. Y	1.21	Richard City, Tenn	1.31
Independence, Kan	1.10	Steelton, Minn	1.61
Ironton, Ohio	1.06	Universal, Pa	1.21
Iola, Kan	1.10	Waco, Tex	1.65
La Salle, Ill	1.10	Wyandotte, Mich	1.20
Limedale, Ind	1.10		

SAND AND GRAVEL—Per ton, delivered. Gravel, sizes ¾-in. or 1½-in.:

	Gravel	Sand
Atlanta	$2.75	$2.25
Baltimore	*2.35*	2.08
Birmingham, per cu.yd., 2,600@2,800 lb.	2.75	2.25
Boston	1.58	1.10
Chicago, per cu.yd., 3,000 lb	1.65	1.65
Cincinnati	1.60	1.35
Cleveland, per cu.yd., 3,000 lb	2.00	2.00
Dallas, per cu.yd., 2,750 lb	2.25	2.25
Denver, per cu.yd., 2,700 lb	1.80	1.35
Detroit	1.65	1.50
Kansas City	2.00	2.00
Los Angeles	2.20	1.60
Minneapolis, per cu.yd., 2,800 lb	2.05	1.00
Montreal	1.50	1.25
New Orleans, per cu.yd., 2,700 lb	2.02½	1.28
New York, per cu.yd., 2,800@3,000 lb.	*2.69*	*1.69*
Philadelphia	2.78	1.98
Pittsburgh	1.55	1.75
St. Louis	1.65	1.35
San Francisco	1.75	1.75
Seattle, per cu.yd., 2,900@3,000 lb	1.85	1.85

CRUSHED STONE—Per ton, size 1½-in., limestone, delivered:

Atlanta	$2.75
Baltimore	2.60
Birmingham	*Slag used*
Boston	1.88
Chicago, per cu.yd., 2,500 lb	1.65
Cincinnati	*1.85*
Cleveland	2.50
Dallas, per cu.yd., 2,500 lb	2.90
Denver, granite, per cu.yd., 2,700 lb	2.50
Detroit	1.95
Kansas City	2.00
Los Angeles	2.20
Minneapolis, per cu.yd., 2,600 lb	2.40
Montreal	*1.75*
New York, per cu.yd., 2,800@3000 lb.	*2.69*
Philadelphia	2.73
Pittsburgh	3.00
St. Louis	1.65
San Francisco, trap rock	1.65
Seattle, per cuyd., 3,000 lb	3.00

CRUSHED SLAG—Prices for carloads, per net ton, at plant:

	1½-In.	¾-In.	Roofing	Sand
Birmingham, Ala	$0.90	$1.15	$2.05	$0.55
Buffalo District	1.25	1.35	2.25	1.25
Cleveland, Ohio	1.10	1.10	2.25	.70
Western Pennsylvania	1.25	1.25	2.00	1.25
Toledo, Ohio	1.10	1.10	1.10	1.00
Youngstown District	1.25	1.35	2.00	1.25

CONCRETE BLOCKS—Standard, 8x8x16-in., hollow, delivered to job, each:

Birmingham (5x8x12)	$0.084	Kansas City	$0.18
Boston	.18	Minneapolis	.10
Brooklyn and Queens	.12	New Orleans	.18
Chicago	.23	Philadelphia	.215
Cleveland	.165	Pittsburgh	.23
Denver	.22	St. Louis	.14
Detroit	.12		

HOLLOW TILE—Building tile per block, delivered to contractors in lots of 2,000 pieces or over:

	4x12x12	6x12x12	8x12x12	10x12x12	12x12x12
Atlanta	$0.09	$0.11	$0.13	$0.20	$0.25
Baltimore	.105	.14	.20	.23	.30
Birmingham	.089	.122	.167	.219	.275
Boston	.08	.115	.145	.21	.265
Chicago	.048	.066	.09	.117	.15
Cincinnati	.06815	.09485	.129	.165	.204
Cleveland	.048	.066	.09	.117	.15
Dallas	.091	.121	.159	.19	.234
Denver	.0975	.135	.175	.2125	.25
Detroit	.08	.11	.145	.19	.235
Kansas City	.088	.11	.145	.19	.235
Los Angeles	.09425	.134	.188	.2325	.2815
Minneapolis	*.075*	*.09895*	*.1232*	*.15025*	*.1775*
New Orleans	.085	.115	.16	.225	.295
New York	.075	.125	.14	.....	.....
Perth Amboy, N. J. (f.o.b.)	.....	.....	.....	.2388	.2936
Philadelphia	.105	.14	.215	.28	.34
Pittsburgh	.0458	.065	.088	.113	.140
St. Louis	.068	.098	.12	.16	.20
San Francisco	.0765	.105	.1765	.....	.....
Seattle	.085	.115	.18	.....	.....

BRICK—Prices delivered per thousand are as follows:

			Paving F.O.B.	
	Common	Face	3x8½x4-in.	3½x8½x4-in.
Atlanta	$14.00	$20.50	$32.00	$37.00
Baltimore	12.50	30.00	40.00	43.00
Birmingham	*12.50*	22.50	27.00	32.00
Boston	13.00	27.50	47.00	52.00
Chicago	12.00	32.50	32.00	38.00
Cincinnati	16.00	24.00	33.00	37.00
Cleveland	13.00	24.50	33.00	36.00
Dallas	13.50	21.00	.....	35.00
Denver	9.50	25.00	.....	.....
Detroit	15.00	25.00	25.00	35.00
Kansas City	14.00	20.00	35.00	37.50
Los Angeles	*8.50*	26.50	.....	.....
Minneapolis	8.50	30.00	.....	.....
Montreal	*16.00*	.....	.....	.....
New Orleans	12.50	.....	40.00	45.00
New York	11.50	30.00	45.00	50.00
Philadelphia	16.00	.....	40.00	45.00
Pittsburgh	12.00	22.00	25.00	25.00
St. Louis	14.00	22.00	*12.00*	*12.00*
San Francisco	14.00	.....	45.00*	.....
Seattle	14.00	.....	48.50	61.00

*2½x8½x4-in.

LIME—Prices delivered to job:

	Hydrated, Per Ton		Lump, Per Barrel	
	Finishing	Common	Finishing	Common
Atlanta	$18.00	$15.00	.....	$2.50†
Baltimore	22.00	14.00	.....	2.25†
Birmingham	30.00	17.50	.....	2.00†
Boston	21.00	14.00	$4.00*	3.10*
Chicago	13.00	12.00	1.50†	1.25†
Cincinnati	*12.60*	*10.40*	.....	.....
Cleveland	12.00	10.00	2.50†	2.50†
Dallas	20.00	.....	2.40†	.....
Denver	30.00	23.75	3.80*	3.00*
Detroit	13.00	12.00	1.65†	1.55†
Kansas City	19.00	18.00	2.25†	2.00†
Los Angeles	26.00	18.00	2.00†	2.00†
Minneapolis	21.00	19.00	.....	1.70†
Montreal	18.00	*8.00*	.....	.....
New Orleans	22.00	13.00	2.10†	1.95†
New York	16.00	13.00	4.10*	3.15*
Philadelphia	18.00	14.50	18.00‡	14.00‡
Pittsburgh	15.00	14.00	4.25*	2.75†
St. Louis	18.00	16.00	12.50‡	12.50‡
San Francisco	17.50	17.50	.....	1.50†
Seattle, paper sacks	35.00	24.00	.....	2.80†

*Per 280-lb. bbl. (net). †Per 180-lb. (net). ‡Per ton.

LIMESTONE—Mill blocks, f.o.b. siding, per cu.ft.:
New York: Rustic buff, $1.37; Standard gray, $1.47; Standard, $1.57; Selected gray, $1.57; Selected buff, $1.67.
Boston: Rustic buff, $1.43; Standard, $1.56; Selected buff, $1.70.
Pittsburgh: Rustic buff, $1.56; Standard, $1.76; Selected buff, $1.86.

SLATE—Roofing, f.o.b. quarry, Bangor, Pa., net, per square:

No. 1 Clear	$8.25@$9.50
No. 1 Ribbon	6.75@ 7.50
Medium Clear	7.25@ 8.00

Road and Paving Materials

PAVING STONE—Granite, lots of 50,000 blocks, 4x8x4-in., dressed, f.o.b. city:

Atlanta	$3.00 per sq.yd.
Baltimore	3.00 per sq.yd.
Birmingham	76.25 per M.
Boston	105.00 per M.
Chicago, 5 in.	3.80 per sq.yd.
Cincinnati	110.00 per M.
Cleveland	95.00 per M.
Detroit, 5 in.	3.00 per sq.yd.
Kansas City	2.75 per sq.yd.
Minneapolis, 4½ in.	2.80 per sq.yd.
Montreal	104.75 per M.
New Orleans	2.80 per sq.yd.
New York, 5 in.	120.00 per M.
Philadelphia	105.00 per M.
St. Louis, 5 in.	3.00 per sq.yd.

Current Prices of Construction Materials

Road and Paving Materials—Continued

WOOD-BLOCK PAVING—Prices, f.o.b., in carloads:

	Size of Block	Treatment	Per Sq.Yd.
Atlanta	3½	16	$2.25
Boston	3½	16	2.25
Chicago	3½	12	1.90
Kansas City	3½	16	2.00
Minneapolis	3½	16	2.50
Montreal	3½	16	2.63
New Orleans	3½	16	2.30
New York	3½	14	1.90
St. Louis	3½	16	2.10

FLAGGING—Alongside dock, New York, per sq.ft.: Manhattan and Bronx, 4 ft. wide, $0.24 Queens, 5 ft. wide, $0.26

CURBING—Prices per lin.ft., f.o.b., cutting charges not included:
New York: Bluestone, f.o.b. barge, straight, 5x16-in., rough, 80 @ 85c.
Birmingham: Granite, straight, 5x16-in., 50c.; 6x20-in., 60c.; roundings, 5x16-in., 65c.; 6x20-in., 80c.
St. Louis: Class "B" straight, 5x16-in., 75c.; roundings, $1.00
Pittsburgh: Sandstone, 6x24-in., 80c.

ASPHALT—Paving asphalt, f.o.b., per ton. Packages are 350-lb. bbl. or 425-lb. drums, in carload lots:

	Packages	Tank-car or -boat
Atlanta	$18.60	$14.60
Baltimore (f.o.b. refinery)	16.00	12.00
Birmingham (f.o.b. refinery)		12.00
Boston	21.00	17.00
Chicago	22.50	15.50
Cincinnati		12.00
Cleveland	18.25	14.50
Dallas	19.50	
Denver	27.50	
Detroit	16.68	12.43
Kansas City (f.o.b. refinery)	16.00	11.00
Los Angeles (f.o.b. refinery)	18.00	12.00
Maurer, N. J. (Bermudez)		25.00
Maurer, N. J. (Trinidad)		21.00
Minneapolis (f.o.b. Twin Cities)	23.30	*16.30*
Montreal	17.00	13.00
New Orleans (f.o.b. refinery)	16.00	12.00
New York (f.o.b. refinery)	16.00	12.00
Philadelphia	16.00	12.00
Pittsburgh	25.00	16.00
St. Louis	*17.70*	*13.20*
San Francisco (f.o.b. refinery)	18.00	12.00
Seattle	21.40	18.00

LIQUID ASPHALT—Residual, prices f.o.b., in tank cars, 8,000 gal. minimum, 45% asphalt, per gal.:

New York	$0.05
Birmingham	.06
St. Louis	.03½
Dallas	.05

Iron and Steel

PIG IRON—Furnace, No. 2 foundry, per gross ton:

	Current	Mo. Ago	Yr. Ago
Birmingham	$10.00@*$11.00*	$10.00@$12.00	$12.00
Buffalo	*14@00 15.00*	15.00@ 16.00	17.50

STRUCTURAL STEEL—Prices per 100 lb., delivered from warehouse except in Birmingham and Pittsburgh, where prices are f.o.b. mill. Beams and channels, 3 to 15 in; angles 3 to 6-in., ¼-in. thick; tees, 3-in. and larger; and plates, ¼-in. thick and heavier:

Birmingham	$1.65	New York	$2.35
Chicago	3.00	Pittsburgh	1.50
Cleveland	2.95	St. Louis	3.25
Dallas	3.25	San Francisco	2.90

BARS, CONCRETE REINFORCING—Prices per 100 lb., delivered from warehouse except in Birmingham and Pittsburgh, where prices are f.o.b. mill, on bars rolled from billets, size ½-in.:

Birmingham	$1.65	New York	$2.35
Chicago	1.65	Pittsburgh	1.50
Cleveland	1.75	St. Louis	3.00
Dallas	2.75	San Francisco	2.50

EXPANDED METAL LATH—Per 100 sq.yd., painted, delivered to job:

Lb. Per Sq.Yd.	New York	Birmingham	Chicago	St. Louis	Dallas	San Francisco
2.2	$15.50	$19.00	$10.60	$17.00	$14.50	*$17.00*
2.5	16.50	20.00	11.40	18.00	16.50	*18.00*
3.0	18.00	22.00	12.65	20.00	....	*19.50*
3.4	19.00	23.50	13.65	21.00	20.00	*21.50*

TRIANGLE MESH—Plain, per 100 sq.ft., 4 in. x 4 in. Manufacturers' quotations are in carloads at mills; dealers' are delivered in lots of 10,000 sq.ft. or over:

Style Number	Weight in Pounds Per 100 Sq.Ft.	Pittsburgh Mill	Chicago District Mill	Del. From Warehouse: New York	St. Louis	Dallas	San Francisco
032	22	$0.94	$0.96	$1.21	$1.31	$1.31	*$1.18*
049	28	1.19	1.22	1.52	*1.66*	1.66	*1.48*
068	35	1.45	1.49	1.85	*2.03*	1.80	*1.82*
093	45	1.87	1.91	2.37	*2.61*	2.30	*2.34*
126	57	2.31	2.37	2.93	*3.24*	2.82	*2.91*
153	68	2.75	2.82	3.48	*3.86*	3.36	....
180	78	3.16	3.24	3.99	....	3.85	....

STEEL SHEETS—Prices per 100 lb. for base sizes, delivered from warehouse, except in Pittsburgh, where prices are f.o.b. mill:

	Hot-rolled No. 10	Hot-rolled* No. 24	Galvanized No. 24
Chicago	$3.20	$3.55	$4.10
Cleveland	3.00	3.60	3.75
New York	2.65	3.50	4.00
Pittsburgh	*1.55*	2.20	2.85
St. Louis	3.45	3.80	4.35
San Francisco	*3.60*	*4.05*	4.65

*Annealed.

WIRE ROPE—Discounts from manufacturers' list prices on regular grades of bright and galvanized, Eastern Territory, New York, and East of Missouri River:

	Base
Cast steel round strand rope	25 %
Galvanized iron rigging and guy rope (add to list)	7 %
Galvanized steel rigging and guy rope	12½ %
Plow steel round strand rope	40 %
"Special Steel" and extra strong cast steel, round strand rope	32½ %

Discount 5 points less than discount for Eastern territory: California, Colorado, Kansas, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Washington and Wyoming. Discount 10 points less than discount for Eastern territory: Arizona, Idaho, Montana and Utah.

RIVETS—Structural rivets, round head, ½-in., full kegs, per 100 lb., delivered from warehouse, except in Pittsburgh, where prices are f.o.b. mill:

Chicago	$3.75
Dallas	4.50
Denver	4.65
New York	4.00
Pittsburgh	2.25
St. Louis	4.00
San Francisco	4.75
Seattle	4.50

STEEL SHEETPILING—Base price, f.o.b., Pittsburgh, for large mill lots, per 100 lb., $1.90

TERNE PLATE—I C, 8-lb. coating, 20x28-in., f.o.b., Pittsburgh mill: Per package, $9.50

SHIP SPIKES—Per 100 lb., black, from warehouse stocks; galvanized are about $1.75 per 100 lb higher:

	½-In.	⅝-In.	¾-In.
San Francisco	$5.50	$5.05	$4.90
Seattle	7.75	5.65	5.50

Pittsburgh mill base in lots of 200 kegs or more, $2.90 per 100 lb.

WIRE NAILS—Per 100 lb. keg, base, delivered from warehouse stocks; also Pittsburgh mill base:

Pittsburgh	Birmingham	Chicago	St. Louis	Dallas	San Francisco	Montreal
$1.95	$2.40	$3.30	$2.40	$3.10	$2.75	*$2.80*

SCRAP—The prices following are f.o.b., per gross ton, paid by dealers:

	New York	Chicago	Detroit
No. 1 railroad wrought	$5.00	*$5.50**	
Stove plate	3.00	*3.25*	$4.50
No. 1 machinery cast	8.50†	*7.00**	7.00*
Machine shop turnings	1.00	*2.50*	*3.25*
Cast borings	1.00	4.00	4.75
Railroad malleable	6.00	*6.50*	
Re-rolling rails	6.00	*9.50*	*8.00*
Heavy melting steel, No. 1	4.25	*7.00*	*6.00*
Iron and steel pipe	*3.00*	*3.25**	

*Net ton. †Delivered direct to foundries.

FREIGHT RATES—The following freight rates per 100 lb., effective Dec. 3 1931, apply on finished steel products in the Pittsburgh district, including plates, structural shapes, merchant-steel bars, pipe fittings, plain and galvanized wire nails, rivets, spikes, bolts, flat sheets (except planished), chains, etc.:

Atlanta	$0.60*	Detroit	$0.285†
Baltimore	.29†	Kansas City	.59†
Birmingham	.60*	New Orleans	.69*
Boston	.42†	New York	.35*
Buffalo	.255†	Pacific Coast (all rail)	1.17‡
Chicago	.36†	Philadelphia	.31†
Cincinnati	.285†	St. Louis	.41†
Cleveland	.205†	St. Paul	.60†
Denver	1.17‡		

*36,000 lb. †40,000 lb. ‡60,000 lb.

Railway Materials and Supplies

STEEL RAILS—Standard rails have been $43.00 per gross ton since Sept., 1922 at which time the price was $40.00; other rails per gross ton, f.o.b., as follows:

	Pittsburgh	Birmingham	Chicago
Light rails	$34.00	$33.00	$34.00
Re-rolled rails	26.00	26.00	32.00

RAILWAY TIES—Prices f.o.b., per tie, for carload lots:

		6 In. x 8 In. by 8 Ft.	7 In. x 9 In. by 8½ Ft.
New York	Long-leaf sap pine, untreated	$0.90	$1.10
	Dense yellow pine, untreated	.70	.90
Birmingham	White oak, untreated	.90	1.05
	White oak, creosoted	1.45	1.55
	Southern pine, untreated	.45	.95
	Southern pine, creosoted	1.05	1.40
Chicago	White oak, untreated	1.05	1.35
	Oak, empty cell, creosoted	1.40	1.80
	Oak, zinc treated	1.25	1.65
	Southern pine, creosoted	1.15	1.50
St. Louis	White oak, untreated	.80	1.30
	Red oak, untreated	.75	1.20
	Red oak, creosoted	1.10	1.85
	Sap pine or cypress, untreated	.65	1.10
San Francisco	Douglas fir, green, untreated	.49	.67
	Douglas fir, empty cell, creosoted	1.22	1.64
Montreal	Birch or maple, untreated	1.00	1.00
	Birch or maple, creosoted	1.25	1.55

Current Prices of Construction Materials

Railway Supplies—Continued

TRACK SUPPLIES—Prices per 100 lb., f.o.b., for large mill lots at Pittsburgh and Birmingham, together with warehouse prices at other places named:

	Pittsburgh	Birmingham	Chicago	St. Louis	San Francisco
Standard spikes, ½-in. and larger	$2.60	$2.70	$3.45	$3.65	$4.10
Track bolts	3.50	3.70	4.30	4.49	5.10
Standard section angle bars, splice bars or fish plates	2.75	3.00*	5.75	.....	.....
Tie plates	1.85	2.07½	1.95†	.....	.....

*At warehouse. †At mill.

Pipe

WROUGHT STEEL PIPE—Discounts from standard lists for delivery from warehouse, except at Pittsburgh, where prices are f.o.b. mill. List prices per ft. as follows: 1-in., 17c; 3-in., 76½c; 3½-in., 92c; 6-in., $1.92.

	1 to 3-In. Butt Weld		3½ to 6-In. Lap Weld	
	Black	Galvanized	Black	Galvanized
Chicago	57.25%	44.71%	53.83%	41.29%
Cleveland	53.3%	42.3%	50.8%	37.8%
New York	56.14%	43.6%	52.72%	40.18%
Pittsburgh	64%	52.5%	61%	49.5%
St. Louis	51%	38%	48%	35%

CAST-IRON PIPE—Prices per net ton, for bell and spigot pipe, Class B and heavier, f.o.b., on regular lots (250 tons and under) of pipe:

	4-In.	6-In. and Over
Birmingham mill	$35.00@$36.00	$32.00@$33.00
Burlington (N. J.) mill	35.00@ 36.00	32.00@ 33.00
Chicago	43.00@ 44.00	40.00@ 41.00
New York	38.00	35.00
Pittsburgh	43.60@ 44.50	40.50@ 41.50
St. Louis	42.80	39.80
San Francisco	43.00@ 44.00	40.00@ 41.00

Gas pipe and Class A, $3.00 per ton extra.

SEWER PIPE—Prices delivered, per foot, for standard pipe; 6, 8 and 12-in. are single strength and 18, 24, 30 and 36-in. are double strength:

	6-In.	8-In.	12-In.	18-In.	24-In.	30-In.	36-In.
Atlanta	$0.125	$0.21	$0.385	.....	$1.40	.....	.....
Baltimore	.10	.30	.58	.....	1.93	.....	$6.50
Birmingham	.18	.30	.54	$1.02	1.95	$3.50	5.00
Boston	.18	.28	.55	1.35	*2.75*	3.95	5.90
Chicago	.18	.28	.54	1.25	2.25	4.75	6.00
Cincinnati	*.108*	.21	*.324*	1.05	*1.75*	*3.528*	5.4325
Cleveland	.1125	.175	.3375	.825	1.485	4.824	7.38
Dallas	.23	.325	.586	1.106	1.95	3.68	5.00
Denver	.161	.23	.414	.816	1.44	.....	.....
Detroit	.135	.21	.405	1.05	2.25	4.10	.....
Kansas City	.21	.335	.52	1.00	1.90	3.60	.....
Los Angeles	.217	.2825	.4985	1.1865	2.034	3.93	.....
Minneapolis	.18	.23	.46	1.20	1.85	3.20	4.26
Montreal	.30	.45	.75	1.95	2.60	.....	7.20
New Orleans	.18	.30	.54	1.02	1.95	.....	.....
New York	.17	.265	.52	1.30	2.34	4.47	6.86
Philadelphia	.0945	.147	.297	.80	1.44	2.304	3.28
Pittsburgh	.09	.18	.27	.62	1.22	2.45	3.68
St. Louis	.147	.235	.423	1.05	.....	3.20	4.40
San Francisco	.175	.25	.45	1.05	1.80	3.00	4.50
Seattle	.22	.30	.54	1.26	2.16	2.50	5.50

CLAY DRAIN TILE—Prices delivered per 1,000 lin.-ft.:

Size, In.	New York	Birm'ham	Pittsburgh	Chicago	St. Louis	San Fran.	Seattle
4	*$40.00**	$50.00	$80.00	$40.00	$50.00	$67.50	$69.00
6	*72.00**	85.00	110.00	100.00	85.00	112.50	112.00

*F.o.b. in full carload quantities.

Miscellaneous

LINSEED OIL—Raw oil, f.o.b., in 1- to 4-bbl. lots, per lb.:
New York $0.074 Minneapolis $0.083

WHITE AND RED LEAD—Base price per 100-lb. keg, f.o.b., New York: White, dry, $12.00; White, in oil, $12.00; Red, dry, $12.00; Red, in oil, $13.50.

CHEMICALS—Water, sewage treatment, road work, f.o.b., carlots, New York:

Bleaching powder, in drums, f.o.b. works, per 100 lb.	$1.75
Calcium chloride, flaked, in drums, f.o.b. works, per ton	21.00
Chlorine, cylinders, per lb.	.04
Silicate of soda, in drums, f.o.b. works, per 100 lb.	1.35
Soda ash, 58%, in bags, per 100 lb.	1.15@1.17½
Sulphate of aluminum, in bags, per 100 lb.	1.25
Sulphate of copper, in bbl., per 100 lb.	*2.75*

MANILA ROPE—The number of feet per pound for the various sizes is as follows: ½-in., 6-ft.; 1-in., 3-ft.; 1½-in., 4-ft., 5-in.; 1¼-in., 3-ft., 8-in.; 1½-in., 2-ft., 5-in.; 1¾-in., 1-ft., 8-in. Following prices are per lb. for ½-in. and larger, in 1,200 ft. coils.

Atlanta	$0.18	Kansas City	$0.23
Baltimore	.225	Los Angeles	.175
Birmingham	.25	Minneapolis	.18
Boston	.20	Montreal	.185
Chicago	.175	New Orleans	.19
Cincinnati	.21	New York	.17
Cleveland	.21	Philadelphia	.21
Dallas	.22	St. Louis	*.17*
Denver	.20	San Francisco	.175
Detroit	*.18*	Seattle	.175

BUILDING PAPER—Black, 50-lb. per roll of 500 sq.ft., in carloads, f.o.b., producing point $2.05

SLATERS FELT—In carloads, per roll, f.o.b., producing point *$0.53*

PREPARED ROOFING—Prices, delivered to contractors, in carloads, f.o.b New York, per square:

Single shingles, slate finish, sufficient to cover 100 sq.ft.	$6.50
Strip shingles, 4 in 1, hexagonal shape, with Underwriters' label	6.25
Slate-surfaced roofing in rolls weighing 85 to 90 lbs.	2.50

ROOFING MATERIALS—Prices, f.o.b. New York, delivered to contractors in carloads:

Asphalt felt, per 100 lb.	$2.40
Tar felt, per 100 lb.	2.40
Asphalt coating, per gal.	.34
Tar pitch, in 350 lb. barrels, per ton	28.00

WINDOW GLASS—Discounts from latest jobbers' window-glass list, dated Sept. 15, 1928, at New York warehouse:

	Single Thickness		Double Thickness	
	A Quality	B Quality	A Quality	B Quality
First 3 brackets	89%	91%	88%	90%
Larger sizes	88%	90%	88%	90%

EXPLOSIVES—Price per pound for dynamite delivered:

	Gelatin 40%	Gelatin 60%		Gelatin 40%	Gelatin 60%
Atlanta	$0.215	$0.2375	Los Angeles	$0.1725	$0.1925
Baltimore	.215	.2375	Minneapolis	.18	.195
Birmingham	*.13*	*.1525*	Montreal	.17	.195
Boston	.225	.25	New Orleans	.195	.22
Chicago	.17	.195	New York	.245	.2675
Cincinnati	.22	.245	Philadelphia	.215	.24
Dallas	.185	.21	St. Louis	.1975	.2175
Denver	.19	.2125	San Francisco	.155	.18
Kansas City, Mo.	.2025	.2225	Seattle	.1525	.175

Lumber

Prices Are Delivered, Per M Ft., B. M., No. 1 Common, Rough

New York—Timbers, to contractors, at site of job in Manhattan, in 20 ft. lengths and under:

	Long-leaf Yellow Pine	Douglas Fir
3x4 to 8x8	$45.00	$27.00
3x10 to 10x10	52.00	28.00
3x12 to 12x12	63.00	28.00
3x14 to 14x14	70.00	33.00

Chicago—Timbers, pine, in 20 ft. lengths and under; fir, up to 32 ft:

	Long-Leaf Yellow Pine	Douglas Fir
3x4 to 8x8	$42.50	$42.50
3x10 to 10x10	49.50	44.50
3x12 to 12x12	62.50	44.52
3x14 to 14x14	72.51	45.50

San Francisco—Douglas fir timbers:

	10-16-18 and 20 Ft.	22 and 24 Ft.
3x3 and 4	$35.00	$37.00
3x6 and 8	35.00	37.00
3x10 and 12	35.00	37.00
3x14	38.00	39.00

Other Cities—Timbers, boards, etc.:

	8x8-In. x 20 Ft. and Under				3x12 to 12x12-In. 20 Ft. and Under	
	Pine	Fir	Hemlock	Spruce	Pine	Fir
Atlanta	$40.00	.....	.....	.....	$50.00	.....
Baltimore	35.00	$48.00	$52.00	$58.50	72.00	$48.00
Birmingham	29.00	.....	.....	.....	33.00	.....
Boston	50.00	46.00	46.50	48.00	53.00	43.00
Cincinnati	*35.00*	*42.50*	.....	.....	*35.00*	*42.50*
Cleveland	54.00	54.00	.....	.....	52.00	52.00
Dallas	55.00	47.50	55.00	55.00	55.00	47.50
Denver	.....	40.50	55.00	.....	.....	49.00
Detroit	53.00	51.00	.....	.....	63.00	51.00
Kansas City	35.00	35.00	35.00	.....	55.00	40.00
Los Angeles	.....	41.50	.....	.....	.....	42.50
Minneapolis	40.00*	40.00	40.00	.....	40.00*	40.00
Montreal	.....	41.75	.....	*26.00*	40.00	41.75
New Orleans	38.00	38.00	.....	43.00	63.00	58.00
Philadelphia	45.00	42.00	36.00	40.00	55.00	40.00
Pittsburgh	48.00	55.00	65.00	66.00	60.00	58.00
St. Louis	*36.00*	*38.09*	*37.00*	.....	*53.00*	*40.00*
Seattle	.....	16.00	.....	.....	.....	15.00

	1x10 In x 16 Ft. and Under			2x10 In. x 16 Ft. T. & Gr.	
	Pine	Fir	Hemlock	Pine	Fir
Atlanta	$45.00	.....	.....	$32.50	.....
Baltimore	52.00	$43.00	$42.00	.....	.....
Birmingham	31.00	.....	.....	33.00	.....
Boston	45.00	41.00	41.50	47.00	$45.00
Cincinnati	*28.00*	47.50	.....	*28.00*	.....
Cleveland	44.00	37.00	37.00	42.00	54.00
Dallas	60.00	.....	.....	55.00	.....
Denver	.....	31.00	36.00	.....	45.00
Detroit	48.00	45.00	.....	43.00	43.00
Kansas City	40.00	40.00	.....	35.00	33.00
Los Angeles	41.50	41.50	.....	.....	48.50
Minneapolis	35.00*	35.00	35.00	35.00*	38.00
Montreal	45.00	43.25	40.00	.....	38.25
New Orleans	39.00	39.00	.....	54.00	48.00
Philadelphia	48.00	40.00	35.00	49.00	40.00
Pittsburgh	40.00	47.00	35.00	40.00	53.00
St. Louis	*37.00*	*40.00*	*38.00*	39.00	42.00
Seattle	.....	15.00	.....	.....	16.00

*West Coast Pine.

PILES—Prices of Nichols Bros., 90 West St., N.Y.C., per linear foot, pine, with bark on, f.o.b., New York; delivered from barge, 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.10	$0.165
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.145	.215
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.17	.235
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.205	.345
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.2225	.295
14 in.—2 ft. from butt	5 in.	80 to 85 ft.	.285	.395
14 in.—2 ft. from butt	5 in.	85 to 89 ft.	.325	.435